RE-N14746A

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 392 506**
A2

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 90106948.4

(51) Int. Cl.5: **G11B 20/14, H03M 7/20**

(22) Date of filing: 11.04.90

(30) Priority: 12.04.89 JP 90537/89
09.02.90 JP 28262/90

(43) Date of publication of application:
17.10.90 Bulletin 90/42

(84) Designated Contracting States:
DE FR GB IT NL

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(54) **Digital modulation method.**

(57) A digital modulation method for modulating 8-bit digital data into 14-bit digital modulation codes. The number of consecutive identical bits in a series of 14-bit digital modulation codes is restricted to 2 - 7. The absolute value of DSV at the end of each 14-bit digital modulation code is restricted to 2 or less, and the absolute value of DSV at each bit of any 14-bit digital modulation codes is limited to 7 or less. The direct current component of the 14-bit modulation codes can be effectively reduced.

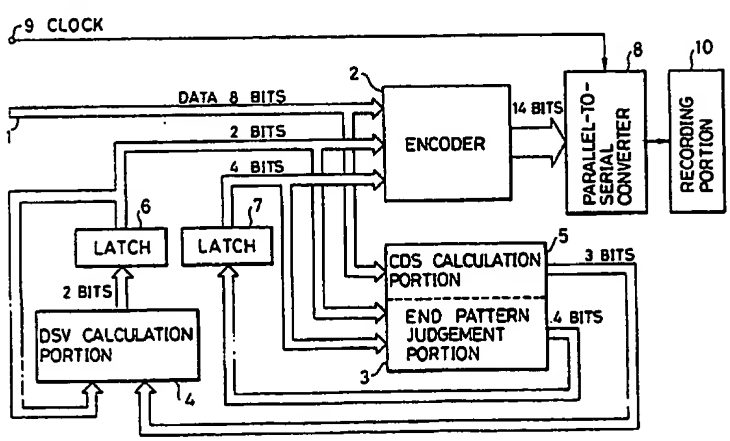

FIG.1

EP 0 392 506 A2

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DIGITAL MODULATION METHOD

The present invention relates to a digital modulation method which converts 8-bit digital data into 14-bit digital modulation codes.

Conventional apparatuses, which use rotary heads to record digital data to magnetic tape or to reproduce digital data recorded on magnetic tape, utilize rotary transformers to record or reproduce the digital data: recording is performed by supplying the digital data to the rotary head through the rotary transformer; and reproduction is performed by reading the digital signal with the rotary magnetic head through the rotary transformer.

Consequently, if the reproduced signal includes a DC (Direct Current) component, the digital data cannot be correctly reproduced. For this reason, the digital data must be recorded by using a DC free digital modulation system.

Among the conventional DC free digital modulation systems, the following systems are well known.

The 8-10 modulation system, the DR (Density Ratio) of which is 0.8, is described in Japanese Patent Application Laying-Open No. 56-19506.

The M^2 modulation system, the DR of which is 1, is known.

The 8-14 modulation system, the DR of which is 1.14, is described in Japanese Patent Application Laying-Open No. 61-196469. This system provides up to four 14-bit digital modulation codes for each 8-bit digital data. When the CDS (Code word Digital Sum) of a 14-bit modulation code is zero, the code is paired with the reversal pattern thereof. When the CDS of a 14-bit digital modulation code is not zero, the code is grouped with the following three codes: another 14-bit modulation code the absolute value and sign of CDS of which differ from those of the above code; and the reversal patterns of the respective codes.

Here, CDS is defined as a DSV calculated from the first bit to the last bit of a modulation code: DSV (Digital Sum Value) is a total sum obtained by adding -1 for respective bits "0" in a series of digital modulation codes and by adding 1 for respective bits "1" in the same codes. The reversal pattern is a pattern obtained by reversing each bit in a code: bit "1" is reversed to "0", whereas bit "0" is reversed to "1".

The above-mentioned conventional modulation systems have the following problems.

The 8-10 modulation system is not appropriate to a high-density recording because of its low DR of 0.8.

The M^2 modulation system is restricted in its high density recording because of its DR of 1.

The 8-14 modulation system has up to 4 modulation codes for each 8-bit code, and the absolute value of CDS of the digital modulation codes are allowed up to 6. In addition, DSV at the end of each 14-bit digital modulation code in the code stream is allowed up to ± 4, and DSV at each bit in a series of the 14-bit digital modulation codes is allowed up to ± 9. Consequently, it is difficult to eliminate the DC component of the modulation codes in a short time, and hence, low frequency component must be adequately passed in a recording/reproducing system including the rotary transformer.

A further problem is presented in the 8-14 modulation system. Generally speaking, magnetizing depth on magnetic tape is about 1/4 of the magnetized wavelength. When recording signals are over-written on the tape, the following problem occurs: recording a new signal of the shortest magnetized wavelength on the longest magnetized wavelength which is 4 times or more longer than the shortest magnetized wavelength results in the erasing residue in the deeper part of the recording medium. This erasing residue appears during reproduction of the new signal, and so the over-writing is practically difficult.

Thus, the 8-14 modulation system suffers from the problem caused by the erasing residue when over-writing is performed because the number of consecutive identical bits ("0" or "1") in a 8-14 modulation code train is 2-9.

Incidentally, in the later description, the term "consecutive identical bits" means two or more consecutive identical bits: for example, "000" or "11".

It is therefore an object of the present invention to provide a digital modulation system which can solve the above problems: the digital modulation system that allows high density recording, that can reduce the DC component with high efficiency, and that can perform azimuth recording and over-writing.

In a first aspect of the present invention, there is provided a digital modulation method for converting 8-bit digital data into 14-bit digital modulation codes, the digital modulation method comprising:

step 1 for selecting up to four 14-bit digital modulation codes for each 8-bit digital data, the 14-bit digital modulation code is selected by the procedures of

(a) selecting among the 2^{14} 14-bit digital codes, a digital code the numbers of consecutive identical bits in which are 5 or less in the first 6 bits, 2 - 7 from the second bit to 13th bit, and 6 or less in the last 7 bits, the absolute value of CDS of the selected digital code being 4 or less, and repeating this selecting

procedure,

(b) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is 0, and pairing the selected 14-bit digital code with the reversal code thereof to make the 2 digital codes one group, or selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "1", and the value of CDS of which is +2 or +4, combining the selected 14-bit digital codes with the reversal codes thereof, and further combining the two 14-bit digital codes with a pair of 14-bit digital codes selected at the above procedure to make the 4 digital codes one group, and repeating this selecting procedure,

(c) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is +2, and another digital code the first bit of which is "1", and the value of CDS of which is +2 or +4, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure,

(d) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is +4, and another digital code the first bit of which is "1", and the value of CDS of which is +2, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure, and

(e) selecting 256 groups among the groups formed in the above procedures as the 14-bit digital modulation codes;

step 2 for selecting one group of 14-bit digital modulation codes among the 256 groups of the 14-bit digital modulation codes, the selected group corresponding to inputted 8-bit digital data;

step 3 for further selecting one or more 14-bit digital modulation codes in the selected group at step 2, each of the 14-bit digital modulation codes satisfying the requirement that the number of consecutive identical bits at the joint portion of the preceding 14-bit digital modulation code already selected and the 14-bit digital modulation code to be selected is 2 - 7; and

step 4 for further selecting one 14-bit digital modulation code among the selected modulation codes at step 3 so that the one 14-bit digital modulation code satisfies the requirement that the absolute value of the DSV at each bit of the modulation code (called bit DSV hereinafter) is equal to or less than 7.

In a second aspect of the present invention, there is provided a digital modulation method for converting 8-bit digital data into 14-bit digital modulation codes, the digital modulation method comprising:

step 1 for selecting up to four 14-bit digital modulation codes for each 8-bit digital data, the 14-bit digital modulation code is selected by the procedures of

(a) selecting among the 2^{14} 14-bit digital codes, a digital code the numbers of consecutive identical bits in which are 6 or less in the first 7 bits, 2 - 7 from the second bit to 13th bit, and 5 or less in the last 6 bits, and repeating this selecting procedure,

(b) selecting among the 14-bit digital codes selected at the procedure (a), a digital code the first bit of which is "0", and the CDS of which has the absolute value equal to or less than 6, and repeating this selecting procedure,

(c) selecting among the 14-bit digital codes selected at the procedure (a), a digital code the first bit of which is "1", and the CDS of which has the absolute value equal to or less than 4, and repeating this selecting procedure,

(d) selecting among the 14-bit digital codes selected at the procedure (b), a digital code the value of CDS of which is 0, and pairing the selected 14-bit digital code with the reversal code thereof to make the 2 digital codes one group, and repeating this selecting procedure,

(e) selecting among the 14-bit digital codes selected at the procedure (b), a digital code the value of CDS of which is +2, +4 or +6, selecting among the 14-bit digital codes selected at the procedure (c), a digital code the value of CDS of which is +2 or +4, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure, and

(f) selecting 256 groups among the groups formed in the above procedures as the 14-bit digital modulation codes;

step 2 for selecting one group of 14-bit digital modulation codes among the 256 groups of the 14-bit digital modulation codes, the selected group corresponding to inputted 8-bit digital data;

step 3 for further selecting one or more 14-bit digital modulation codes in the selected group at step 2, each of the 14-bit digital modulation codes satisfying the requirement that the number of consecutive identical bits at the joint portion of the preceding 14-bit digital modulation code already selected and the 14-bit digital modulation code to be selected is 2 - 7; and

step 4 for further selecting one 14-bit digital modulation code among the selected modulation codes at step 3 so that the one 14-bit digital modulation code satisfies the requirement that the absolute value of

the bit DSV of the modulation code is equal to or less than 8.

Fig. 1 is a block diagram showing a digital modulation apparatus for carrying out the digital modulation according to the first embodiment of the digital modulation method of the present invention;

Fig. 2 is a block diagram showing an embodiment of the decoding circuit;

Fig. 3A is a graph showing a carrier-to-noise ratio of a reproduced signal;

Fig. 3B is a graph showing a power spectrum of the first embodiment of the present invention;

Fig. 3C is a graph showing a power spectrum of the scrambled NRZ;

Fig. 4 is a view showing the number of 14-bit digital modulation codes whose CDS ≥ 0;

Fig. 5 is a view showing the number of 14-bit digital modulation codes whose CDS ≤ 0;

Fig. 6 is a block diagram showing a digital modulation apparatus for carrying out the digital modulation according to the second embodiment of the digital modulation method of the present invention;

Fig. 7 is a flowchart showing the modulation procedure of the digital modulation apparatus for carrying out the digital modulation according to the second embodiment;

Fig. 8 is a view showing the number of 14-bit digital modulation codes whose CDS ≥ 0; and

Fig. 9 is a view showing the number of 14-bit digital modulation codes whose CDS ≤ 0.

The invention will now be described with reference to the accompanying drawings.

[A] FIRST EMBODIMENT

Fig. 1 is a block diagram showing a digital modulation apparatus for carrying out the digital modulation according to the first embodiment of the digital modulation method of the present invention.

In Fig. 1, 8-bit digital data 1 is converted to a 14-bit digital modulation code by an encoder 2. An end pattern judgement portion 3 converts the end pattern of the last 6-bits of the 14-bit digital modulation code into a 4-bit code in Table 9 (although the last 8 bits of the modulation codes are given in Table 9, only the last 6 bits should be considered). A CDS calculation portion 5 computes the CDS of the 14-bit digital modulation code supplied, and converts the resultant CDS into a 3-bit code in Table 7. A DSV calculation portion 4 adds the CDS of the current 14-bit digital modulation code to the DSV at the end of the preceding 14-bit digital modulation code, yielding a new DSV, and converts the new DSV into a 2-bit code shown in Table 8.

A parallel-to-serial converter 8 converts the 14-bit digital modulation code into a serial signal in synchronism with a clock signal 9. A recording portion 10 records the serial modulation signal produced from the parallel-to-serial converter 8 on a recording medium such as magnetic tape or the like.

TABLE 7

CDS of modulation codes	Corresponding 3-bit codes
-4	000
-2	001
0	010
2	011
4	100

TABLE 8

DSV at the end of the preceding modulation codes	Corresponding 2-bit codes
-2	00
0	01
2	10

TABLE 9

End pattern of the preceding modulation code	Corresponding 2-bit codes
... xxxxx110	0000
... xxxx1100	0001
... xxx11000	0010
... xx110000	0011
... x1100000	0100
... 11000000	0101
... xxxxx001	0110
... xxxx0011	0111
... xxx00111	1000
... xx001111	1001
... x0011111	1010
... 00111111	1011
x: Don't care bit	

The output code of the CDS calculation portion 5 is supplied to the DSV calculation portion 4.

The DSV calculation portion 4 supplies the code to the encoder 2 via a latch 6. The end pattern judgement portion 3 supplies the code to the encoder 2 via a latch 7.

Next, the method for selecting a 14-bit digital modulation code corresponding to each inputted 8-bit digital data will be described.

First, the method for selecting up to four 14-bit digital modulation codes for each 8-bit digital data will be described. The 14-bit digital modulation code is selected by the procedures of

(a) selecting among the 2^{14} 14-bit digital codes, a digital code the numbers of consecutive identical bits in which are 5 or less in the first 6 bits, 2 - 7 from the second bit to 13th bit, and 6 or less in the last 7 bits, the absolute value of CDS of the selected digital code being 4 or less, and repeating this selecting procedure,

(b) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is 0, and pairing the selected 14-bit digital code with the reversal code thereof to make the 2 digital codes one group, and repeating this selecting procedure, or selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "1", and the value of CDS of which is +2 or +4, combining the selected 14-bit digital codes with the reversal codes thereof, and further combining the two 14-bit digital codes with a pair of 14-bit digital codes

selected at the above procedure to make the 4 digital codes one group, and repeating this selecting procedure,

(c) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is +2, and another digital code the first bit of which is "1", and the value of CDS of which is +2 or +4, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure,

(d) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is +4, and another digital code the first bit of which is "1", and the value of CDS of which is +2, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure, and

(e) selecting 256 groups among the groups formed in the above procedures as the 14-bit digital modulation codes.

Next, the selection procedure of a 14-bit digital modulation code (current modulation code) corresponding to inputted 8-bit data will be described.

First, the DSV at the end of the preceding modulation code is calculated, and the end pattern of the preceding modulation code is decided as one of the twelve end patterns shown in Table 9.

Subsequently, the current 14-bit digital modulation code is selected by the encoder 2 in response to the 8-bit data, the DSV at the end of the preceding modulation code, and the end pattern of the preceding modulation code.

More specifically, the following steps are taken for selecting the current 14-bit digital modulation code.

(1) The 14-bit digital modulation codes satisfying the following conditions are selected from Tables 4 and 5: (a) the number of consecutive identical bits at the joint portion with the preceding 14-bit digital modulation code is two to seven; and (b) the absolute value of the DSV at the end of the digital modulation code (called end DSV hereinafter) is equal to or less than two.

(2) When two or more 14-bit digital modulation codes are selected at step (1), the 14-bit digital modulation code that gives the least absolute value of the end DSV is chosen.

(3) When two or more 14-bit digital modulation codes are still chosen in step (2), the 14-bit digital modulation code is selected by calculating the bit DSV of the modulation code, determining the bit DSV the absolute value of which is minimum for each modulation code, and choosing the code including the bit DSV whose minimum absolute value is minimum.

(4) When two or more 14-bit digital modulation codes are further found in step (3), the 14-bit digital modulation code is selected by finding the maximum absolute value of the bit DSV of each modulation code, and choosing the code including the bit DSV whose maximum absolute value is equal to or less than six.

(5) When two or more modulation code are still found in step (4), is selected the 14-bit digital modulation code satisfying the condition that the number of consecutive identical bits at the joint portion with the preceding 14-bit digital modulation code is equal to or less than six.

(6) When any modulation codes selected at step (4) does not satisfy step (5), or two or more modulation codes satisfy step (5), is selected a 14-bit digital modulation code satisfying the condition that the consecutive identical bits in that modulation code is equal to or less than six.

(7) When any modulation code selected at step (4) does not satisfy steps (5) and (6), or when any modulation code selected at step (5) does not satisfy step (6), or when two or more modulation codes are further found at step (6), the following steps are taken.

(7a) When the end DSV of the modulation code is -2, the code of higher priority (corresponding to smaller number in Table 10) is selected according to Table 10. Likewise, when the end DSV of the modulation code is +2, the code of higher priority is selected according to Table 11.

(7b) When two or more modulation codes belonging to the equal highest priority are found in step (7a), all of them are temporarily selected. When the end DSV is zero, is selected the modulation code satisfying the last six bits of which are not "...111111", nor "...000000" in the modulation codes.

(8) When any modulation code selected at step (4) does not satisfy steps (5), (6) and (7), or when any modulation code selected at step (5) does not satisfy step (6) and (7), or when any modulation code selected at step (6) does not satisfy step (7), or when two or more modulation codes are further found at step (7), is selected the modulation code including the bit DSV whose maximum absolute value is minimum.

(9) When two or more modulation codes are still found at step (8), is selected the modulation code including the bit DSV whose minimum absolute value appears fastest in the bit string of the modulation code.

(10) When two or more modulation codes are further found at step (9), is selected the modulation code whose bit will be reversed fastest after the joint point with the preceding modulation code.

TABLE 10

In the case where DSV at the end of modulation code is "-2"	
End pattern of modulation codes	Priority
... xxxxx001	4
... xxxx0011	1
... xxx00111	2
... xx001111	3
... x0011111	8
... xxxxx110	10
... xxxx1100	5
... xxx11000	6
... xx110000	7
... x1100000	9
... 11000000	11
x: Don't care bit	

TABLE 11

In the case where DSV at the end of modulation code is "+2"	
End pattern of modulation codes	Priority
... xxxxx110	4
... xxxx1100	1
... xxx11000	2
... xx110000	3
... x1100000	8
... xxxxx001	10
... xxxx0011	5
... xxx00111	6
... xx001111	7
... x0011111	9
... 00111111	11
x: Don't care bit	

The 14-bit digital modulation code thus selected is fed to the parallel-to-serial converter 8. The modulation code entered the parallel-to-serial converter 8 is serially read out in synchronism with the clock 9, and is fed to the recording portion 10, where the 14-bit digital modulation code is recorded on the recording medium such as magnetic tape or the like.

On the other hand, the 14-bit digital modulation code selected by the encoder 2 is supplied to the DSV calculation portion 4, and to the end pattern judgement portion 3. The DSV calculation portion 4 adds the CDS of the current modulation code to the DSV at the end of the preceding modulation code to obtain a new DSV. The new DSV is converted into a 2-bit code according to Table 8, and is supplied to the encoder 2 through latch 6. The end pattern judgement portion 3 converts the last 6 bits of the 14-bit modulation code into a 4-bit code according to Table 9, and supplies the 4-bit code to the encoder 2 through latch 7.

The above procedure is repeated for every 8-bit input data. Thus, a 14-bit digital modulation code train is obtained, in which the number of consecutive identical bits is restricted to 2 - 7, and the absolute value of the DSV is restricted equal to or less than 7.

Fig. 2 shows an example of the decoding circuit. In Fig. 2, reference numeral 11 designates a reproducing portion, 12 designates a synchronizing signal detector, 13 denotes a serial-to-parallel converter, and 14 denotes a decoder. The decoding procedure by the decoding circuit will now be described.

The serial modulation code reproduced by the reproducing portion 11 is supplied to the synchronizing signal detector 12 and the serial-to-parallel converter 13. The synchronizing signal detector 12 detects the synchronizing signal inserted at the beginning of the synchronizing block, and supplies it to the parallel-to-serial portion 13. The synchronizing signal is used to synchronize with each 14-bit digital modulation code. The serial-to-parallel converter 13, using the synchronizing signal from the synchronizing signal detector 12, converts the serial 14-bit digital modulation code to a parallel 14-bit digital modulation code, and supplies it to the decoder 14. The decoder 14 decodes the 14-bit digital modulation code into corresponding 8-bit data by using a ROM.

Next, the 14-bit digital modulation code produced from the encoder 2 in Fig. 1 will be described.

The 14-bit digital modulation code converted from the 8-bit code satisfies the following requirements.

(1) The number of consecutive identical bits in the first 6 bits is equal to or less than 5.

(2) The number of consecutive identical bits included from the second bit to the 13th bit is 2 - 7.

(3) The number of consecutive identical bits included in the last 7 bits is equal to or less than 6.

(4) The absolute value of CDS of the modulation code is equal to or less than 4.

The end patterns of the modulation codes that satisfy the above requirements (1) to (4) are summed up as the following 12 items (A) - (M).

(A)	... ...	110
(B)	... ...	1100
(C)	... ...	11000
(D)	... ...	110000
(E)	... ...	1100000
(F)	... ...	11000000
(G)	... ...	001
(H)	... ...	0011
(J)	... ...	00111
(K)	... ...	001111
(L)	... ...	0011111
(M)	... ...	00111111

The beginning of the modulation code succeeding to the modulation codes (A) - (M) is one of the following items.

First, the beginning of the modulation code succeeding to the modulation code (A) is one of the following five items (A1) - (A5).

(A1) 011 ··· ··· ··· ···
(A2) 0011··· ··· ··· ···
(A3) 00011 ··· ··· ···
(A4) 000011 ··· ··· ···
(A5) 0000011 ··· ···

Second, the beginning of the modulation code succeeding to the modulation code (B) is one of the following nine items (B1) - (B9).

(B1) 011 ··· ··· ··· ···
(B2) 0011··· ··· ··· ···
(B3) 00011 ··· ··· ···
(B4) 000011 ··· ··· ···
(B5) 0000011 ··· ···
(B6) 1100··· ··· ··· ···
(B7) 11100 ··· ··· ···
(B8) 111100 ··· ··· ···
(B9) 1111100 ··· ···

The beginning of the modulation code succeeding to the modulation code (C) is one of the following eight items (C1) - (C8) .

(C1) 011 ··· ··· ··· ···
(C2) 0011··· ··· ··· ···
(C3) 00011 ··· ··· ···
(C4) 000011 ··· ··· ···
(C5) 1100··· ··· ··· ···
(C6) 11100 ··· ··· ···
(C7) 111100 ··· ··· ···
(C8) 1111100 ··· ···

The beginning of the modulation code succeeding to the modulation code (D) is one of the following seven items (D1) - (D7).

(D1) 011 ··· ··· ··· ···
(D2) 0011··· ··· ··· ···
(D3) 00011 ··· ··· ···

(D4) 1100··· ··· ··· ···
(D5) 11100 ··· ··· ···
(D6) 111100 ··· ··· ···
(D7) 1111100 ··· ···

The beginning of the modulation code succeeding to the modulation code (E) is one of the following six items (E1) - (E6).

(E1) 011 ··· ··· ··· ···
(E2) 0011··· ··· ··· ···
(E3) 1100··· ··· ··· ···
(E4) 11100 ··· ··· ···
(E5) 111100 ··· ··· ···
(E6) 1111100 ··· ···

The beginning of the modulation code succeeding to the modulation code (F) is one of the following five items (F1) - (F5).

(F1) 011 ··· ··· ··· ···
(F2) 1100··· ··· ··· ···
(F3) 11100 ··· ··· ···
(F4) 111100 ··· ··· ···
(F5) 1111100 ··· ···

The beginning of the modulation code succeeding to the modulation code (G) is one of the reversal patterns of the modulation codes (A1) - (A5).

The beginning of the modulation code succeeding to the modulation code (H) is one of the reversal patterns of the modulation codes (B1) - (B9).

The beginning of the modulation code succeeding to the modulation code (J) is one of the reversal patterns of the modulation codes (C1) - (C8).

The beginning of the modulation code succeeding to the modulation code (K) is one of the reversal patterns of the modulation codes (D1) - (D7).

The beginning of the modulation code succeeding to the modulation code (L) is one of the reversal patterns of the modulation codes (E1) - (E6).

The beginning of the modulation code succeeding to the modulation code (M) is one of the reversal patterns of the modulation codes (F1) - (F5).

The numbers of the modulation codes that satisfy the requirements (1) - (4) are shown in Tables 1 and 2. The code "10000000111111" (CDS = 0), and the code "01111111000000" (CDS = 0) are excluded from the numbers.

TABLE 1

Beginning pattern of modulation codes	The number of possible modulation codes							
	CDS Value							
	-4	-2	0	2	4	Total	CDS ≤ 0	CDS ≥ 0
0000011......	9	8	6	0	0	23	23	6
000011.......	12	14	10	6	0	42	36	16
00011.........	15	21	20	11	5	72	56	36
0011..........	17	29	33	26	11	116	79	70
011............	17	37	49	47	32	182	103	128
Total	70	109	118	90	48	435	297	256

TABLE 2

Beginning pattern of modulation codes	The number of possible modulation codes							
	CDS Value							
	-4	-2	0	2	4	Total	CDS ≤ 0	CDS ≥ 0
1111100......	0	0	6	8	9	23	6	23
111100.......	0	6	10	14	12	42	16	36
11100.........	5	11	20	21	15	72	36	56
1100..........	11	26	33	29	17	116	70	79
100............	32	47	49	37	17	182	128	103
Total	48	90	118	109	70	435	256	297

More than 256 modulation codes whose CDS ≥ 0, and more than 256 modulation codes whose CDS ≤ 0 are necessary, which follow one of the modulation codes (A) - (M). In addition, the converted modulation code must correspond to one 8-bit data to avoid transmission error.

The number of modulation codes that can succeed one of the modulation codes (A) - (M) is shown in Table 3.

For example, the CDS of the modulation codes that terminate with "...00111111" is "2" or "4". Accordingly, the end DSV of the modulation code takes a value of "0" or "2", and so the succeeding modulation code must satisfy the requirements that its CDS ≤ 0, and it must begin with any one of the bit train "0000011", "000011, "00011", "0011", and "100". The number of the modulation codes that satisfy the requirements are 322 as shown in Table 3, which is greater than the necessary number of 256.

Likewise, the CDS of the modulation codes that terminate with "...11000000" is "-2" or "-4". Accordingly, the end DSV of the modulation code takes a value of "0" or "-2", and so the succeeding modulation code must satisfy the requirements that its CDS ≥ 0, and it must begin with any one of the bit train "1111100", "111100", "11100", "1100", and "011". The number of the modulation codes that satisfy the requirements are 322 as shown in Table 3, which is greater than the necessary number of 256.

TABLE 3

End pattern of modulation codes	The number of possible successive modulation codes							
	CDS Value							
	-4	-2	0	2	4	Total	CDS ≤ 0	CDS ≥ 0
..........110	70	109	118	90	48	435	297	256
........1100	86	152	187	162	101	688	425	450
.......11000	77	144	181	162	101	665	402	444
.....110000	65	130	171	156	101	623	366	428
...1100000	50	109	151	145	96	551	310	392
..11000000	33	80	118	119	85	435	231	322
.........001	48	90	118	109	70	435	256	297
........0011	101	162	187	152	86	688	450	425
.......00111	101	162	181	144	77	665	444	402
......001111	101	156	171	130	65	623	428	366
....0011111	96	145	156	109	50	550	392	310
...00111111	85	119	118	80	33	435	322	231

Fig. 4 shows the number of modulation codes of respective classes when CDS ≥ 0, and Fig. 5 shows the number of modulation code of respective classes when CDS ≤ 0.

Tables 4 and 5 show the correspondence between the 8-bit data and the modulation codes: Table 4 shows the correspondence when CDS ≥ 0; and Table 5 shows the correspondence when CDS ≤ 0.

Table 4 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	0	01111110000001	0		0	10000001111110	0
	1	01111100110000	0		1	10000011001111	0
	2	01111100011000	0		2	10000011100111	0
	3	01111100001100	0		3	10000011110011	0
	4	01111100000110	0		4	10000011111001	0
	5	01111100000011	0		5	10000011111100	0
	6	01111001110000	0		6	10000110001111	0
	7	01111001100001	0		7	10000110011110	0
	8	01111000111000	0		8	10000111000111	0
	9	01111000110001	0		9	10000111001110	0
	10	01111000011100	0		10	10000111100011	0
	11	01111000011001	0		11	10000111100110	0
	12	01111000001110	0		12	10000111110001	0
	13	01111000000111	0		13	10000111111000	0
	14	01110011110000	0		14	10001100001111	0
	15	01110011100001	0		15	10001100011110	0
	16	01110011001100	0		16	10001100110011	0
	17	01110011000110	0		17	10001100111001	0
	18	01110011000011	0		18	10001100111100	0
	19	01110001111000	0		19	10001110000111	0
	20	01110001110001	0		20	10001110001110	0
	21	01110001100110	0		21	10001110011001	0
	22	01110001100011	0		22	10001110011100	0
	23	01110000111100	0		23	10001111000011	0
	24	01110000111001	0		24	10001111000110	0
	25	01110000110011	0		25	10001111001100	0
	26	01110000011110	0		26	10001111100001	0
	27	01110000001111	0		27	10001111110000	0
	28	01100111110000	0		28	10011000001111	0
	29	01100111100001	0		29	10011000011110	0
	30	01100111001100	0		30	10011000110011	0
	31	01100111000110	0		31	10011000111001	0
	32	01100111000011	0		32	10011000111100	0
	33	01100110011100	0		33	10011001100011	0
1(A)	34	01100110011001	0	1(B)	34	10011001100110	0
	35	01100110001110	0		35	10011001110001	0
	36	01100110000111	0		36	10011001111000	0
	37	01100011111000	0		37	10011100000111	0
	38	01100011110001	0		38	10011100001110	0
	39	01100011100110	0		39	10011100011001	0
	40	01100011100011	0		40	10011100011100	0
	41	01100011001110	0		41	10011100110001	0
	42	01100011000111	0		42	10011100111000	0
	43	01100001111100	0		43	10011110000011	0
	44	01100001111001	0		44	10011110000110	0
	45	01100001110011	0		45	10011110001100	0
	46	01100001100111	0		46	10011110011000	0
	47	01100000111110	0		47	10011111000001	0
	48	01100000011111	0		48	10011111100000	0
	49	01111111001100	4		49	10000011111110	2
	50	01111111000110	4		50	10000110011111	2
	51	01111111000011	4		51	10000111001111	2
	52	01111110011100	4		52	10000111100111	2
	53	01111110011001	4		53	10000111110011	2
	54	01111110001110	4		54	10000111111001	2
	55	01111110000111	4		55	10000111111100	2
	56	01111100111100	4		56	10001100011111	2
	57	01111100111001	4		57	10001100111110	2
	58	01111100110011	4		58	10001110001111	2
	59	01111100011110	4		59	10001110011110	2
	60	01111100001111	4		60	10001111000111	2
	61	01111001111100	4		61	10001111001110	2
	62	01111001111001	4		62	10001111100011	2
	63	01111001110011	4		63	10001111100110	2

Table 4 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	64	01111001100111	4		64	10001111110001	2
	65	01111000111110	4		65	10001111111000	2
	66	01111000011111	4		66	10011000011111	2
	67	01110011111100	4		67	10011000111110	2
	68	01110011111001	4		68	10011001100111	2
	69	01110011110011	4		69	10011001110011	2
	70	01110011100111	4		70	10011001111001	2
	71	01110011001111	4		71	10011001111100	2
	72	01110001111110	4		72	10011100001111	2
	73	01110000111111	4		73	10011100011110	2
	74	01100111111100	4		74	10011100110011	2
	75	01100111111001	4		75	10011100111001	2
	76	01100111110011	4		76	10011100111100	2
	77	01100111100111	4		77	10011110000111	2
	78	01100111001111	4		78	10011110001110	2
	79	01100110011111	4	1(B)	79	10011110011001	2
	80	01100011111110	4		80	10011110011100	2
	81	01111111000001	2		81	10011111000011	2
	82	01111110011000	2		82	10011111000110	2
	83	01111110001100	2		83	10011111001100	2
	84	01111110000110	2		84	10011111100001	2
	85	01111110000011	2		85	10011111110000	2
	86	01111100111000	2		86	10001111001111	4
	87	01111100110001	2		87	10001111100111	4
	88	01111100011100	2		88	10001111110011	4
	89	01111100011001	2		89	10011001111110	4
	90	01111100001110	2		90	10011100111110	4
	91	01111100000111	2		91	10011110001111	4
	92	01111001111000	2		92	10011110011110	4
	93	01111001110001	2		93	10011111000111	4
	94	01111001100110	2		94	10011111001110	4
	95	01111001100011	2		95	10011111100011	4
	96	01111000111100	2		96	10011111100110	4
	97	01111000111001	2		97	11000111100111	4
1(A)	98	01111000110011	2		98	11000111110011	4
	99	01111000011110	2		99	11000000111111	2
	100	01111000001111	2		100	11000001111110	2
	101	01110011111000	2		101	11000011001111	2
	102	01110011110001	2		102	11000011100111	2
	103	01110011100110	2		103	11000011110011	2
	104	01110011100011	2		104	11000011111001	2
	105	01110011001110	2		105	11000011111100	2
	106	01110011000111	2		106	11000110001111	2
	107	01110001111100	2		107	11000110011110	2
	108	01110001111001	2		108	11000111000111	2
	109	01110001110011	2	2(B)	109	11000111001110	2
	110	01110001100111	2		110	11000111100011	2
	111	01110000111110	2		111	11000111100110	2
	112	01110000011111	2		112	11000111110001	2
	113	01100111111000	2		113	11000111111000	2
	114	01100111110001	2		114	11001100001111	2
	115	01100111100110	2		115	11001100011110	2
	116	01100111100011	2		116	11001100110011	2
	117	01100111001110	2		117	11001100111001	2
	118	01100111000111	2		118	11001100111100	2
	119	01100110011110	2		119	11001110000111	2
	120	01100110001111	2		120	11001110001110	2
	121	01100011111100	2		121	11001110011001	2
	122	01100011111001	2		122	11001110011100	2
	123	01100011110011	2		123	11001111000011	2
	124	01100011100111	2		124	11001111000110	2
	125	01100011001111	2		125	11001111001100	2
	126	01100001111110	2		126	11001111100001	2
	127	01100000111111	2		127	11001111110000	2

Table 4 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
2(A)	128	00111111100000	0	2(B)	128	11000000011111	0
	129	00111111000001	0		129	11000000111110	0
	130	00111110011000	0		130	11000001100111	0
	131	00111110001100	0		131	11000001110011	0
	132	00111110000110	0		132	11000001111001	0
	133	00111110000011	0		133	11000001111100	0
	134	00111100111000	0		134	11000011000111	0
	135	00111100110001	0		135	11000011001110	0
	136	00111100011100	0		136	11000011100011	0
	137	00111100011001	0		137	11000011100110	0
	138	00111100001110	0		138	11000011110001	0
	139	00111100000111	0		139	11000011111000	0
	140	00111001111000	0		140	11000110000111	0
	141	00111001110001	0		141	11000110001110	0
	142	00111001100110	0		142	11000110011001	0
	143	00111001100011	0		143	11000110011100	0
	144	00111000111100	0		144	11000111000011	0
	145	00111000111001	0		145	11000111000110	0
	146	00111000110011	0		146	11000111001100	0
	147	00111000011110	0		147	11000111100001	0
	148	00111000001111	0		148	11000111110000	0
	149	00110011111000	0		149	11001100000111	0
	150	00110011110001	0		150	11001100001110	0
	151	00110011100110	0		151	11001100011001	0
	152	00110011100011	0		152	11001100011100	0
	153	00110011001110	0		153	11001100110001	0
	154	00110011000111	0		154	11001100111000	0
	155	00110001111100	0		155	11001110000011	0
	156	00110001111001	0		156	11001110000110	0
	157	00110001110011	0		157	11001110001100	0
	158	00110001100111	0		158	11001110011000	0
	159	00110000111110	0		159	11001111000001	0
	160	00110000011111	0		160	11001111100000	0
	161	00111111100001	2		161	11001100111110	4
	162	00111111001100	2		162	11001110011110	4
	163	00111111000110	2		163	11001111000111	4
	164	00111111000011	2		164	11001111001110	4
	165	00111110011100	2		165	11001111100011	4
	166	00111110011001	2		166	11001111100110	4
	167	00111110001110	2	3(B)	167	11100001111110	4
	168	00111110000111	2		168	11100011100111	4
	169	00111100111100	2		169	11100011110011	4
	170	00111100111001	2		170	11100011111100	4
	171	00111100110011	2		171	11100110011110	4
	172	00111100011110	2		172	11100111000111	4
	173	00111100001111	2		173	11100111001110	4
	174	00111001111100	2		174	11100111100011	4
	175	00111001111001	2		175	11100111100110	4
	176	00111001110011	2		176	11100111111000	4
	177	00111001100111	2		177	11100000011111	2
	178	00111000111110	2		178	11100000111110	2
	179	00111000011111	2		179	11100001100111	2
	180	00110011111100	2		180	11100001110011	2
	181	00110011111001	2		181	11100001111001	2
	182	00110011110011	2		182	11100001111100	2
	183	00110011100111	2		183	11100011000111	2
	184	00110011001111	2		184	11100011001110	2
	185	00110001111110	2		185	11100011100011	2
	186	00110000111111	2		186	11100011100110	2
	187	00111111100110	4		187	11100011110001	2
	188	00111111100011	4		188	11100011111000	2
	189	00111111001110	4		189	11100110000111	2
	190	00111111000111	4		190	11100110001110	2
	191	00111110011110	4		191	11100110011001	2

Table 4 (CDS ≧ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
2(A)	192	00111110001111	4	3(B)	192	11100110011100	2
	193	00111100111110	4		193	11100111000011	2
	194	00111100011111	4		194	11100111000110	2
	195	00111001111110	4		195	11100111001100	2
	196	00111000111111	4		196	11100111100001	2
	197	00110011111110	4		197	11100111110000	2
3(A)	198	00011111110000	0		198	11100000001111	0
	199	00011111100001	0		199	11100000011110	0
	200	00011111001100	0		200	11100000110011	0
	201	00011111000110	0		201	11100000111001	0
	202	00011111000011	0		202	11100000111100	0
	203	00011110011100	0		203	11100001100011	0
	204	00011110011001	0		204	11100001100110	0
	205	00011110001110	0		205	11100001110001	0
	206	00011110000111	0		206	11100001111000	0
	207	00011100111100	0		207	11100011000011	0
	208	00011100111001	0		208	11100011000110	0
	209	00011100110011	0		209	11100011001100	0
	210	00011100011110	0		210	11100011100001	0
	211	00011100001111	0		211	11100011110000	0
	212	00011001111100	0		212	11100110000011	0
	213	00011001111001	0		213	11100110000110	0
	214	00011001110011	0		214	11100110001100	0
	215	00011001100111	0		215	11100110011000	0
	216	00011000111110	0		216	11100111000001	0
	217	00011000011111	0		217	11100111100000	0
	218	00011111110001	2	4(B)	218	11110001111100	4
	219	00011111100110	2		219	11110011111000	4
	220	00011111100011	2		220	11110000001111	2
	221	00011111001110	2		221	11110000011110	2
	222	00011111000111	2		222	11110000110011	2
	223	00011110011110	2		223	11110000111001	2
	224	00011110001111	2		224	11110000111100	2
	225	00011100111110	2		225	11110001100011	2
	226	00011100011111	2		226	11110001100110	2
	227	00011001111110	2		227	11110001110001	2
	228	00011000111111	2		228	11110001111000	2
	229	00011111110011	4		229	11110011000011	2
	230	00011111100111	4		230	11110011000110	2
	231	00011111001111	4		231	11110011001100	2
	232	00011110011111	4		232	11110011100001	2
	233	00011100111111	4		233	11110011110000	2
4(A)	234	00001111111000	0		234	11110000000111	0
	235	00001111110001	0		235	11110000001110	0
	236	00001111100110	0		236	11110000011001	0
	237	00001111100011	0		237	11110000011100	0
	238	00001111001110	0		238	11110000110001	0
	239	00001111000111	0		239	11110000111000	0
	240	00001110011110	0		240	11110001100001	0
	241	00001110001111	0		241	11110001110000	0
	242	00001100111110	0		242	11110011000001	0
	243	00001100011111	0		243	11110011100000	0
	244	00001111111001	2	5(B)	244	11111000000111	2
	245	00001111110011	2		245	11111000001110	2
	246	00001111100111	2		246	11111000011001	2
	247	00001111001111	2		247	11111000011100	2
	248	00001110011111	2		248	11111000111000	2
	249	00001100111111	2		249	11111001110000	2
5(A)	250	00000111111100	0		250	11111000000011	0
	251	00000111111001	0		251	11111000000110	0
	252	00000111110011	0		252	11111000001100	0
	253	00000111100111	0		253	11111000011000	0
	254	00000111001111	0		254	11111000110000	0
	255	00000110011111	0		255	11111001100000	0

Table 5 (CDS ≦ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	0	01111110000001	0		0	10000001111110	0
	1	01111100110000	0		1	10000011001111	0
	2	01111100011000	0		2	10000011100111	0
	3	01111100001100	0		3	10000011110011	0
	4	01111100000110	0		4	10000011111001	0
	5	01111100000011	0		5	10000011111100	0
	6	01111001110000	0		6	10000110001111	0
	7	01111001100001	0		7	10000110011110	0
	8	01111000111000	0		8	10000111000111	0
	9	01111000110001	0		9	10000111001110	0
	10	01111000011100	0		10	10000111100011	0
	11	01111000011001	0		11	10000111100110	0
	12	01111000001110	0		12	10000111110001	0
	13	01111000000111	0		13	10000111111000	0
	14	01110011110000	0		14	10001100001111	0
	15	01110011100001	0		15	10001100011110	0
	16	01110011001100	0		16	10001100110011	0
	17	01110011000110	0		17	10001100111001	0
	18	01110011000011	0		18	10001100111100	0
	19	01110001111000	0		19	10001110000111	0
	20	01110001110001	0		20	10001110001110	0
	21	01110001100110	0		21	10001110011001	0
	22	01110001100011	0		22	10001110011100	0
	23	01110000111100	0		23	10001111000011	0
	24	01110000111001	0		24	10001111000110	0
	25	01110000110011	0		25	10001111001100	0
	26	01110000011110	0		26	10001111100001	0
	27	01110000001111	0		27	10001111110000	0
	28	01100111110000	0		28	10011000001111	0
	29	01100111100001	0		29	10011000011110	0
	30	01100111001100	0		30	10011000110011	0
	31	01100111000110	0		31	10011000111001	0
	32	01100111000011	0		32	10011000111100	0
	33	01100110011100	0		33	10011001100011	0
1(C)	34	01100110011001	0	1(D)	34	10011001100110	0
	35	01100110001110	0		35	10011001110001	0
	36	01100110000111	0		36	10011001111000	0
	37	01100011111000	0		37	10011100000111	0
	38	01100011110001	0		38	10011100001110	0
	39	01100011100110	0		39	10011100011001	0
	40	01100011100011	0		40	10011100011100	0
	41	01100011001110	0		41	10011100110001	0
	42	01100011000111	0		42	10011100111000	0
	43	01100001111100	0		43	10011110000011	0
	44	01100001111001	0		44	10011110000110	0
	45	01100001110011	0		45	10011110001100	0
	46	01100001100111	0		46	10011110011000	0
	47	01100000111110	0		47	10011111000001	0
	48	01100000011111	0		48	10011111100000	0
	49	01111100000001	-2		49	10000000110011	-4
	50	01111001100000	-2		50	10000000111001	-4
	51	01111000110000	-2		51	10000000111100	-4
	52	01111000011000	-2		52	10000001100011	-4
	53	01111000001100	-2		53	10000001100110	-4
	54	01111000000110	-2		54	10000001110001	-4
	55	01111000000011	-2		55	10000001111000	-4
	56	01110011100000	-2		56	10000011000011	-4
	57	01110011000001	-2		57	10000011000110	-4
	58	01110001110000	-2		58	10000011001100	-4
	59	01110001100001	-2		59	10000011100001	-4
	60	01110000111000	-2		60	10000011110000	-4
	61	01110000110001	-2		61	10000110000011	-4
	62	01110000011100	-2		62	10000110000110	-4
	63	01110000011001	-2		63	10000110001100	-4

Table 5 (CDS ≤ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
1(C)	64	01110000001110	-2	1(D)	64	10000110011000	-4
	65	01110000000111	-2		65	10000111000001	-4
	66	01100111100000	-2		66	10000111100000	-4
	67	01100111000001	-2		67	10001100000011	-4
	68	01100110011000	-2		68	10001100000110	-4
	69	01100110001100	-2		69	10001100001100	-4
	70	01100110000110	-2		70	10001100011000	-4
	71	01100110000011	-2		71	10001100110000	-4
	72	01100011110000	-2		72	10001110000001	-4
	73	01100011100001	-2		73	10001111000000	-4
	74	01100011001100	-2		74	10011000000011	-4
	75	01100011000110	-2		75	10011000000110	-4
	76	01100011000011	-2		76	10011000001100	-4
	77	01100001111000	-2		77	10011000011000	-4
	78	01100001110001	-2		78	10011000110000	-4
	79	01100001100110	-2		79	10011001100000	-4
	80	01100001100011	-2		80	10011100000001	-4
	81	01100000111100	-2		81	10000000111110	-2
	82	01100000111001	-2		82	10000001100111	-2
	83	01100000110011	-2		83	10000001110011	-2
	84	01100000011110	-2		84	10000001111001	-2
	85	01100000001111	-2		85	10000001111100	-2
	86	01110000110000	-4		86	10000011000111	-2
	87	01110000011000	-4		87	10000011001110	-2
	88	01110000001100	-4		88	10000011100011	-2
	89	01100110000001	-4		89	10000011100110	-2
	90	01100011000001	-4		90	10000011110001	-2
	91	01100001110000	-4		91	10000011111000	-2
	92	01100001100001	-4		92	10000110000111	-2
	93	01100000111000	-4		93	10000110001110	-2
	94	01100000110001	-4		94	10000110011001	-2
	95	01100000011100	-4		95	10000110011100	-2
	96	01100000011001	-4		96	10000111000011	-2
2(C)	97	00111000011000	-4		97	10000111000110	-2
	98	00111000001100	-4		98	10000111001100	-2
	99	00111111000000	-2		99	10000111100001	-2
	100	00111110000001	-2		100	10000111110000	-2
	101	00111100110000	-2		101	10001100000111	-2
	102	00111100011000	-2		102	10001100001110	-2
	103	00111100001100	-2		103	10001100011001	-2
	104	00111100000110	-2		104	10001100011100	-2
	105	00111100000011	-2		105	10001100110001	-2
	106	00111001110000	-2		106	10001100111000	-2
	107	00111001100001	-2		107	10001110000011	-2
	108	00111000111000	-2		108	10001110000110	-2
	109	00111000110001	-2		109	10001110001100	-2
	110	00111000011100	-2		110	10001110011000	-2
	111	00111000011001	-2		111	10001111000001	-2
	112	00111000001110	-2		112	10001111100000	-2
	113	00111000000111	-2		113	10011000000111	-2
	114	00110011110000	-2		114	10011000001110	-2
	115	00110011100001	-2		115	10011000011001	-2
	116	00110011001100	-2		116	10011000011100	-2
	117	00110011000110	-2		117	10011000110001	-2
	118	00110011000011	-2		118	10011000111000	-2
	119	00110001111000	-2		119	10011001100001	-2
	120	00110001110001	-2		120	10011001110000	-2
	121	00110001100110	-2		121	10011100000011	-2
	122	00110001100011	-2		122	10011100000110	-2
	123	00110000111100	-2		123	10011100001100	-2
	124	00110000111001	-2		124	10011100011000	-2
	125	00110000110011	-2		125	10011100110000	-2
	126	00110000011110	-2		126	10011110000001	-2
	127	00110000001111	-2		127	10011111000000	-2

Table 5 (CDS ≦ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	128	00111111100000	0		128	11000000011111	0
	129	00111111000001	0		129	11000000111110	0
	130	00111110011000	0		130	11000001100111	0
	131	00111110001100	0		131	11000001110011	0
	132	00111110000110	0		132	11000001111001	0
	133	00111110000011	0		133	11000001111100	0
	134	00111100111000	0		134	11000011000111	0
	135	00111100110001	0		135	11000011001110	0
	136	00111100011100	0		136	11000011100011	0
	137	00111100011001	0		137	11000011100110	0
	138	00111100001110	0		138	11000011110001	0
	139	00111100000111	0		139	11000011111000	0
	140	00111001111000	0		140	11000110000111	0
	141	00111001110001	0		141	11000110001110	0
	142	00111001100110	0		142	11000110011001	0
2(C)	143	00111001100011	0		143	11000110011100	0
	144	00111000111100	0		144	11000111000011	0
	145	00111000111001	0		145	11000111000110	0
	146	00111000110011	0		146	11000111001100	0
	147	00111000011110	0		147	11000111100001	0
	148	00111000001111	0		148	11000111110000	0
	149	00110011111000	0		149	11001100000111	0
	150	00110011110001	0		150	11001100001110	0
	151	00110011100110	0		151	11001100011001	0
	152	00110011100011	0		152	11001100011100	0
	153	00110011001110	0		153	11001100110001	0
	154	00110011000111	0		154	11001100111000	0
	155	00110001111100	0		155	11001110000011	0
	156	00110001111001	0		156	11001110000110	0
	157	00110001110011	0		157	11001110001100	0
	158	00110001100111	0		158	11001110011000	0
	159	00110000111110	0		159	11001111000001	0
	160	00110000011111	0		160	11001111100000	0
	161	00110011000001	-4		161	11000000011110	-2
	162	00110001100001	-4	2(D)	162	11000000110011	-2
	163	00110000111000	-4		163	11000000111001	-2
	164	00110000110001	-4		164	11000000111100	-2
	165	00110000011100	-4		165	11000001100011	-2
	166	00110000011001	-4		166	11000001100110	-2
	167	00011110000001	-4		167	11000001110001	-2
	168	00011100011000	-4		168	11000001111000	-2
	169	00011100001100	-4		169	11000011000011	-2
	170	00011100000011	-4		170	11000011000110	-2
	171	00011001100001	-4		171	11000011001100	-2
	172	00011000111000	-4		172	11000011100001	-2
	173	00011000110001	-4		173	11000011110000	-2
	174	00011000011100	-4		174	11000110000011	-2
3(C)	175	00011000011001	-4		175	11000110000110	-2
	176	00011000000111	-4		176	11000110001100	-2
	177	00011111100000	-2		177	11000110011000	-2
	178	00011111000001	-2		178	11000111000001	-2
	179	00011110011000	-2		179	11000111100000	-2
	180	00011110001100	-2		180	11001100000011	-2
	181	00011110000110	-2		181	11001100000110	-2
	182	00011110000011	-2		182	11001100001100	-2
	183	00011100111000	-2		183	11001100011000	-2
	184	00011100110001	-2		184	11001100110000	-2
	185	00011100011100	-2		185	11001110000001	-2
	186	00011100011001	-2		186	11001111000000	-2
	187	00011100001110	-2		187	11000000011001	-4
	188	00011100000111	-2		188	11000000011100	-4
	189	00011001111000	-2		189	11000000110001	-4
	190	00011001110001	-2		190	11000000111000	-4
	191	00011001100110	-2		191	11000001100001	-4

Table 5 (CDS ≦ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	192	00011001100011	-2		192	11000001110000	-4
	193	00011000111100	-2		193	11000011000001	-4
	194	00011000111001	-2		194	11000011100000	-4
	195	00011000110011	-2		195	11000110000001	-4
	196	00011000011110	-2	2(D)	196	11000111000000	-4
	197	00011000001111	-2		197	11001100000001	-4
	198	00011111110000	0		198	11100000001111	0
	199	00011111100001	0		199	11100000011110	0
	200	00011111001100	0		200	11100000110011	0
	201	00011111000110	0		201	11100000111001	0
3(C)	202	00011111000011	0		202	11100000111100	0
	203	00011110011100	0		203	11100001100011	0
	204	00011110011001	0		204	11100001100110	0
	205	00011110001110	0		205	11100001110001	0
	206	00011110000111	0		206	11100001111000	0
	207	00011100111100	0		207	11100011000011	0
	208	00011100111001	0		208	11100011000110	0
	209	00011100110011	0		209	11100011001100	0
	210	00011100011110	0		210	11100011100001	0
	211	00011100001111	0		211	11100011110000	0
	212	00011001111100	0		212	11100110000011	0
	213	00011001111001	0		213	11100110000110	0
	214	00011001110011	0		214	11100110001100	0
	215	00011001100111	0	3(D)	215	11100110011000	0
	216	00011000111110	0		216	11100111000001	0
	217	00011000011111	0		217	11100111100000	0
	218	00001110000011	-4		218	11100000001110	-2
	219	00001100000111	-4		219	11100000011001	-2
	220	00001111110000	-2		220	11100000011100	-2
	221	00001111100001	-2		221	11100000110001	-2
	222	00001111001100	-2		222	11100000111000	-2
	223	00001111000110	-2		223	11100001100001	-2
	224	00001111000011	-2		224	11100001110000	-2
	225	00001110011100	-2		225	11100011000001	-2
4(C)	226	00001110011001	-2		226	11100011100000	-2
	227	00001110001110	-2		227	11100110000001	-2
	228	00001110000111	-2		228	11100111000000	-2
	229	00001100111100	-2		229	11100000001100	-4
	230	00001100111001	-2		230	11100000011000	-4
	231	00001100110011	-2		231	11100000110000	-4
	232	00001100011110	-2		232	11100001100000	-4
	233	00001100001111	-2		233	11100011000000	-4
	234	00001111111000	0		234	11110000000111	0
	235	00001111110001	0		235	11110000001110	0
	236	00001111100110	0		236	11110000011001	0
	237	00001111100011	0		237	11110000011100	0
	238	00001111001110	0		238	11110000110001	0
	239	00001111000111	0		239	11110000111000	0
	240	00001110011110	0		240	11110001100001	0
	241	00001110001111	0		241	11110001110000	0
	242	00001100111110	0	4(D)	242	11110011000001	0
	243	00001100011111	0		243	11110011100000	0
	244	00000111111000	-2		244	11110000000110	-2
	245	00000111110001	-2		245	11110000001100	-2
	246	00000111100110	-2		246	11110000011000	-2
	247	00000111100011	-2		247	11110000110000	-2
	248	00000111000111	-2		248	11110001100000	-2
	249	00000110001111	-2		249	11110011000000	-2
5(C)	250	00000111111100	0		250	11111000000011	0
	251	00000111111001	0		251	11111000000110	0
	252	00000111110011	0		252	11111000001100	0
	253	00000111100111	0	5(D)	253	11111000011000	0
	254	00000111001111	0		254	11111000110000	0
	255	00000110011111	0		255	11111001100000	0

The modulation codes in 5(B) of Table 4 can be changed as shown in Table 12 to improve the end DSV: the six modulation codes whose CDS = 0 in 5(B) is reduced to four by two, and two new modulation codes which have not been used and whose CDS = 2 are added.

TABLE 12

8-bit data	Modulation codes	CDS
248	11111000110001	2
249	11111000111000	2
250	11111001100001	2
251	11111001110000	2

Selecting a modulation code whose CDS = 2 makes it possible to adjust the end DSV at the end of the selected modulation code to 0, when the end DSV at the end of the preceding modulation code is -2, the last bit pattern of the preceding code is any one of the patterns "01", "100", "1000", "10000", "100000", and "1000000", and the signal data is 250 or 251. The modulation codes in 5(C) of Table 5, which are the reversal codes of those in 5(B) of Table 4, can also be changed as shown in Table 13.

TABLE 13

8-bit data	Modulation codes	CDS
248	00000111001110	-2
249	00000111000111	-2
250	00000110011110	-2
251	00000110001111	-2

Modulation codes which are not used in Tables 4 and 12, and whose CDS = 4 can be used in place of the modulation codes in Table 4 or in Tables 4 and 12. Selecting a modulation code whose CDS = 4 when the end DSV at the end of the preceding modulation code is -2 can improve the bit DSV of the selected modulation code because the bit DSV is sure to take 0 at a particular bit in the selected modulation code.

The modulation codes in Table 5 and Table 13, which are reversal patterns of the codes in Table 4 and Table 12, can be changed in a manner similar to the above, resulting in a similar improvement.

The modulation codes specified to correspond to 8-bit data in Tables 4 and 5 are an example, and so the combination of the modulation codes and the 8-bit code can be altered.

Types of the modulation codes that are allowed to take place according to the end pattern of the preceding modulation code are shown in Table 6.

TABLE 6

		Consecutive number of "0" bits at the beginning of modulation code					Consecutive number of "1" bits at the beginning of modulation code				
End pattern of the preceding modulation codes	CDS≧0	1 (A)	2 (A)	3 (A)	4 (A)	5 (A)	1 (B)	2 (B)	3 (B)	4 (B)	5 (B)
	CDS≦0	1 (C)	2 (C)	3 (C)	4 (C)	5 (C)	1 (D)	2 (D)	3 (D)	4 (D)	5 (D)
	110	o	o	o	o	o					
	1100	o	o	o	o	o		o	o	o	o
	11000	o	o	o	o			o	o	o	o
	110000	o	o	o				o	o	o	o
	1100000	o	o					o	o	o	o
	...11000000*	o						o	o	o	o
	001							o	o	o	o
	0011		o	o	o	o	o	o	o	o	o
	00111		o	o	o	o	o	o	o	o	
	001111		o	o	o	o	o	o	o		
	0011111		o	o	o	o	o	o			
	...00111111*		o	o	o	o	o				

Notes with regard to Table 6:

"o" mark indicates that the modulation codes are allowed.

"*" indicates that a modulation code whose CDS ≧ 0 is selected when the end pattern of the preceding modulation code is "...11000000", and that a modulation code whose CDS ≦ 0 is selected when the end pattern of the preceding modulation code is "...00111111".

For example, when the end pattern of the preceding modulation code is "...11000", and the end DSV of

the preceding modulation code is -2, the modulation codes of classes 1(A), 2(A), 3(A), 4(A), 2(B), 3(B), 4(B), and 5(B) in Table 4 can take place as a current modulation code because the current modulation code to be selected must satisfy the requirements that the CDS ≥ 0 and the number of consecutive identical bits in the joint portion of the two codes is 2 - 7.

In this case, suppose that the current 8-bit data is "166". Then, one of the two possible modulation codes "00111110011001" (CDS = 2; 2(A)), and "11001111100110" (CDS = 4; 2(B)) shown in Table 4 is selected: the end DSV of the preceding modulation code and the CDS of the current modulation code are added so as to obtain the end DSV of the current modulaticn code; the modulation code which will give less end DSV is selected, that is, the modulation code "00111110011001" (CDS = 2) is selected. The resultant end DSV is 0 and it indicates that the direct current component is removed.

Fig. 3A shows the CNR (carrier-to-noise ratio) characteristics when a sine wave recorded on magnetic tape is reproduced, Fig. 3B shows the power spectrum at the output terminal of the modulator of the embodiment when random 8-bit data are inputted to the modulator, and Fig. 3C shows the power spectrum of the scrambled NRZ at the output terminal of the scrambled NRZ modulator when random 8-bit data are inputted to the scrambled NRZ modulator. From these figures, it is seen that the power spectrum according to the digital modulation method of the present invention includes no direct current component, and is included within a record-reproduction bandwidth in which the high CNR is obtained. As a result, the record-reproduction characteristics of the magnetic tape and head system can be effectively used. Furthermore, the minimum magnetization transition width of the modulation codes of the digital modulation method according to the present invention is 1.14 times the minimum magnetization transition width of the scrambled NRZ. Consequently, the intercode interference can be reduced.

As described above, the embodiment restricts the number of consecutive identical bits in a stream of modulation codes to 2 - 7. As a result, the minimum magnetization transition width is 1.14T (= (28)T/14, where T is the bit period of the 8-bit data), the maximum magnetization transition width is 4.00T (= (7 × 8)-T/14), DR is 1.14 (=(2 × 8)/14), and the ratio of the maximum magnetization transition width to the minimum magnetization transition width is 3.5. Consequently, the bit error rate of the magnetic recording is reduced, and the high-density recording becomes possible. In addition, azimuth recording and high quality over-writing become possible.

Furthermore, the embodiment restricts the absolute value of CDS of the modulation codes equal to or less than 4, allocates up to 4 modulation codes to each 8-bit data according to the DSV at the end of the preceding modulation code and the end pattern of the preceding code, and selects the modulation code the end DSV of which gives the least absolute value. As a result, the absolute value of the end DSV which is calculated at the end of each modulation code is within 2, and the absolute value of the bit DSV which is calculated at each bit of a modulation code is within 7. Thus, the direct current component can be effectively removed, and hence, the transmission of the modulation codes becomes possible by using a rotary transformer that does not pass the direct current component.

[B] SECOND EMBODIMENT

Fig. 6 is a block diagram showing a digital modulation apparatus for carrying out the digital modulation according to the second embodiment of the digital modulation method of the present invention.

In Fig. 6, 8-bit digital data 1 is converted to a 14-bit digital modulation code by an encoder 2. An end pattern judgement portion 3 converts the end pattern of the last 5-bits of the 14-bit digital modulation code into a 4-bit code in Table 21 (although the last 7 bits of the modulation codes are given in Table 21, only the last 5 bits should be considered). A CDS calculation portion 5 computes the CDS of the 14-bit digital modulation code supplied, and converts the resultant CDS into a 3-bit code in Table 20. A DSV calculation portion 4 adds the CDS of the current 14-bit digital modulation code to the DSV at the end of the preceding 14-bit digital modulation code, yielding a new DSV, and converts the new DSV into a 3-bit code shown in Table 20.

A parallel-to-serial converter 8 converts the 14-bit digital modulation code into a serial signal in synchronism with a clock signal 9. A recording portion 10 records the serial modulation signal produced from the parallel-to-serial converter 8 on a recording medium such as magnetic tape or the like.

TABLE 20

CDS, DSV of modulation codes	Corresponding 3-bit codes
-6	000
-4	001
-2	010
0	011
2	100
4	101
6	110

TABLE 21

End pattern of the preceding modulation codes	Corresponding 4-bit codes
... xxxx110	0000
... xxx1100	0001
... xx11000	0010
... x110000	0011
... 1100000	0100
... xxxx001	1000
... xxx0011	1001
... xx00111	1010
... x001111	1011
... 0011111	1100
x: Don't care bit	

The resultant CDS converted into a 3-bit code shown in Table 20 by the CDS calculation portion 5, is supplied to the DSV calculation portion 4.

The DSV calculation portion 4 converts the resultant DSV into a 3-bit code shown in Table 20, and supplies the code to the encoder 2 via a latch 6. The end pattern judgement portion 3 converts the last five bits into a 4-bit code in Table 21, and supplies the code to the encoder 2 via a latch 7.

Next, the method for selecting a 14-bit digital modulation code corresponding to each inputted 8-bit digital data will be described.

First, the method for selecting up to four 14-bit digital modulation codes for each 8-bit digital data will be described.

The 14-bit digital modulation code is selected by the procedures of

(a) selecting among the 2^{14} 14-bit digital codes, a digital code the numbers of consecutive identical bits in which are 6 or less in the first 7 bits, 2 - 7 from the second bit to 13th bit, and 5 or less in the last 6 bits, and repeating this selecting procedure,

(b) selecting among the 14-bit digital codes selected at the procedure (a), a digital code the first bit of which is "0", and the CDS of which has the absolute value equal to or less than 6, and repeating this

selecting procedure,

(c) selecting among the 14-bit digital codes selected at the procedure (a), a digital code the first bit of which is "1", and the CDS of which has the absolute value equal to or less than 4, and repeating this selecting procedure,

(d) selecting among the 14-bit digital codes selected at the procedure (b), a digital code the value of CDS of which is 0, and pairing the selected 14-bit digital code with the reversal code thereof to make the 2 digital codes one group, and repeating this selecting procedure,

(e) selecting among the 14-bit digital codes selected at the procedure (b), a digital code the value of CDS of which is +2, +4 or +6, selecting among the 14-bit digital codes selected at the procedure (c), a digital code the value of CDS of which is +2 or +4, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure, and

(f) selecting 256 groups among the groups formed in the above procedures as the 14-bit digital modulation codes.

Next, the selection procedure of a 14-bit digital modulation code (current modulation code) corresponding to inputted 8-bit data will be described with reference to Fig. 7, which is a flowchart showing the modulation procedure according to the digital modulation method of the present invention.

At step S1, DSV at the end of the preceding modulation code is calculated.

At step S2, the end pattern of the preceding modulation code is judged.

At step S3, when the DSV < 0, the modulation codes in Table 17 are selected, and when DSV > 0, the modulation codes in Table 18 are selected. On the other hand, when DSV = 0 and the end pattern of the preceding code is any one of "...110", "...0011", "...00111", "...001111", and "...0011111", the modulation codes in Table 18 are selected. Further, when DSV = 0 and the end pattern of the preceding code is any one of "...1100", "...11000", "...110000", "...1100000", and "...001", the modulation codes in Table 17 are selected.

At step S4, a modulation code is selected among the selected codes at step S3 and among the classes 1(A) - 6(D) in Tables 17 and 18, according to the end pattern of the preceding modulation code.

At step S5, is selected a modulation code which gives DSV the absolute value of which is minimum when two or more modulation codes are selected at step S4. In this case, the DSV is obtained by adding the DSV at the end of the preceding modulation code and the CDS of the current modulation code.

At step S6, a modulation code that satisfies the following requirements is selected when two or more modulation codes selected at step S5 have the same minimum DSV.

When DSV < 0 at the end of the preceding modulation code, a modulation code whose first bit is "1" is selected.

When DSV > 0 at the end of the preceding modulation code, a modulation code whose first bit is "0" is selected.

When DSV = 0 at the end of the preceding modulation code, a modulation code whose first bit is opposite to the last bit of the preceding modulation code.

The 14-bit digital modulation code thus selected is fed to the parallel-to-serial converter 8. The modulation code entered the parallel-to-serial converter 8 is serially read out in synchronism with the clock 9, and is fed to the recording portion 10, where the 14-bit digital modulation code is recorded on the record medium such as magnetic tape or the like.

On the other hand, the 14-bit digital modulation code selected by the encoder 2 is supplied to the DSV calculation portion 4, and to the modulation code end pattern judgement portion 3. The DSV calculation portion 4 adds the CDS of the current modulation code to the DSV at the end of the preceding modulation code to obtain a new DSV. The new DSV is converted into a 3-bit code according to Table 20, and is supplied to the encoder 2 through latch 6. The end pattern judgement portion 3 converts the last 5 bits of the 14-bit modulation code into a 4-bit code according to Table 21, and supplies the 4-bit code to the encoder 2 through latch 7.

The above procedure is repeated for every 8-bit input data. Thus, a 14-bit digital modulation code train is obtained, in which the number of consecutive identical bits is restricted to 2 - 7, and the absolute value of the DSV is restricted equal to or less than 8.

Next, the 14-bit digital modulation code produced from the encoder 2 in Fig. 6 will be described.

The 14-bit digital modulation code converted from the 8-bit code satisfies the following requirements.

(1) The number of consecutive identical bits in the first 7 bits is equal to or less than 6.

(2) The number of consecutive identical bits included from the second bit to the 13th bit is 2 - 7.

(3) The number of consecutive identical bits included in the last 6 bits is equal to or less than 5.

(4) The absolute value of CDS of the modulation code is equal to or less than 6.

The end patterns of the modulation codes that satisfy the above requirements (1) to (4) are summed up as the following 10 items (A) - (K).

(A) ··· ··· ··· 110
(B) ··· ··· ··· 1100
(C) ··· ··· ··· 11000
(D) ··· ··· ··· 110000
(E) ··· ··· ··· 1100000
(F) ··· ··· ··· 001
(G) ··· ··· ··· 0011
(H) ··· ··· ··· 00111
(J) ··· ··· ··· 001111
(K) ··· ··· ··· 0011111

The beginning of the modulation code succeeding to the modulation codes (A) - (K) is one of the following items.

First, the beginning of the modulation code succeeding to the modulation code (A) is one of the following five items (A1) - (A6).

(A1) 011 ··· ··· ··· ···
(A2) 0011··· ··· ··· ···

(A3) 00011 ··· ··· ···
(A4) 000011 ··· ··· ···
(A5) 0000011 ··· ···
(A6) 00000011 ··· ···

Second, the beginning of the modulation code succeeding to the modulation code (B) is one of the following ten items (B1) - (B10).

(B1) 011 ··· ··· ··· ···
(B2) 0011··· ··· ··· ···
(B3) 00011 ··· ··· ···
(B4) 000011 ··· ··· ···
(B5) 0000011 ··· ···
(B6) 1100··· ··· ··· ···
(B7) 11100 ··· ··· ···
(B8) 111100 ··· ··· ···
(B9) 1111100 ··· ···
(B10) 11111100 ··· ···

The beginning of the modulation code succeeding to the modulation code (C) is one of the following nine items (C1) - (C9).

(C1)	011 ··· ··· ··· ···
(C2)	0011··· ··· ··· ···
(C3)	00011 ··· ··· ···
(C4)	000011 ··· ··· ···
(C5)	1100··· ··· ··· ···
(C6)	11100 ··· ··· ···
(C7)	111100 ··· ··· ···
(C8)	1111100 ··· ···
(C9)	11111100 ··· ···

The beginning of the modulation code succeeding to the modulation code (D) is one of the following eight items (D1) - (D8).

(D1)	011 ··· ··· ··· ···
(D2)	0011··· ··· ··· ···
(D3)	00011 ··· ··· ···
(D4)	1100··· ··· ··· ···
(D5)	11100 ··· ··· ···
(D6)	111100 ··· ··· ···
(D7)	1111100 ··· ···
(D8)	11111100 ··· ···

The beginning of the modulation code succeeding to the modulation code (E) is one of the following seven items (E1) - (E7).

(E1)	011 ··· ··· ··· ···
(E2)	0011··· ··· ··· ···
(E3)	1100··· ··· ··· ···
(E4)	11100 ··· ··· ···
(E5)	111100 ··· ··· ···
(E6)	1111100 ··· ···
(E7)	11111100 ··· ···

The beginning of the modulation code succeeding to the modulation code (F) is one of the reversal patterns of the modulation codes (A1) - (A6).

The beginning of the modulation code succeeding to the modulation code (G) is one of the reversal patterns of the modulation codes (B1) - (B10).

The beginning of the modulation code succeeding to the modulation code (H) is one of the reversal patterns of the modulation codes (C1) - (C9).

The beginning of the modulation code succeeding to the modulation code (J) is one of the reversal

patterns of the modulation codes (D1) - (D8).

The beginning of the modulation code succeeding to the modulation code (K) is one of the reversal patterns of the modulation codes (E1) - (E7).

The numbers of the modulation codes that satisfy the requirements (1) - (4) are shown in Tables 14 and 15.

TABLE 14

Beginning pattern of modulation codes	The number of possible modulation codes									
	CDS Value									
	-6	-4	-2	0	2	4	6	Total	CDS ≤ 0	CDS ≥ 0
00000011..	5	6	5	1	0	0	0	17	17	1
0000011....	6	9	8	6	0	0	0	29	29	6
000011.....	6	12	14	10	5	0	0	47	42	15
00011.......	7	14	21	20	10	4	0	76	62	34
0011........	5	17	28	33	25	10	3	121	83	71
011..........	4	15	37	49	46	31	8	190	105	134
Total	33	73	113	119	86	45	11	480	338	261

TABLE 15

Beginning pattern of modulation codes	The number of possible modulation codes									
	CDS Value									
	-6	-4	-2	0	2	4	6	Total	CDS ≤ 0	CDS ≥ 0
11111100..	0	0	0	1	5	6	5	17	1	17
1111100....	0	0	0	6	8	9	6	29	6	29
111100.....	0	0	5	10	14	12	6	47	15	42
11100.......	0	4	10	20	21	14	7	76	34	62
1100........	3	10	25	33	28	17	5	121	71	83
100..........	8	31	46	49	37	15	4	190	134	105
Total	11	45	86	119	113	73	33	480	261	338

More than 256 modulation codes whose CDS ≥ 0, and more than 256 modulation codes whose CDS ≤ 0 are necessary, which follow one of the modulation codes (A) - (K). In addition, the converted modulation code must correspond to one 8-bit data to avoid transmission error.

The number of modulation codes that can succeed one of the modulation codes (A) - (K) is shown in Table 16.

TABLE 16

End pattern of modulation codes	The number of possible successive modulation codes									
	CDS Value									
	-6	-4	-2	0	2	4	6	Total	CDS ≤ 0	CDS ≥ 0
.........110	33	73	113	119	86	45	11	480	338	261
.......1100	31	81	148	188	162	103	40	753	448	493
......11000	25	72	140	182	162	103	40	724	419	487
....110000	19	60	126	172	157	103	40	677	377	472
...1100000	12	46	105	152	147	99	40	601	315	438
.........001	11	45	86	119	113	73	33	480	261	338
.......0011	40	103	162	188	148	81	31	753	493	448
......00111	40	103	162	182	140	72	25	724	487	419
....001111	40	103	157	172	126	60	19	677	472	377
...0011111	40	99	147	157	105	46	12	601	438	315

Fig. 8 shows the number of modulation codes of respective classes when CDS ≥ 0, and Fig. 9 shows the number of modulation code of respective classes when CDS ≤ 0.

Tables 17 and 18 show the correspondence between the 8-bit data and the modulation codes: Table 17 shows the correspondence when CDS ≥ 0; and Table 18 shows the correspondence when CDS ≤ 0.

Table 17 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	0	01111110000001	0		0	10000001111110	0
	1	01111100110000	0		1	10000011001111	0
	2	01111100011000	0		2	10000011100111	0
	3	01111100001100	0		3	10000011110011	0
	4	01111100000110	0		4	10000011111001	0
	5	01111100000011	0		5	10000011111100	0
	6	01111001110000	0		6	10000110001111	0
	7	01111001100001	0		7	10000110011110	0
	8	01111000111000	0		8	10000111000111	0
	9	01111000110001	0		9	10000111001110	0
	10	01111000011100	0		10	10000111100011	0
	11	01111000011001	0		11	10000111100110	0
	12	01111000001110	0		12	10000111110001	0
	13	01111000000111	0		13	10000111111000	0
	14	01110011110000	0		14	10001100001111	0
	15	01110011100001	0		15	10001100011110	0
	16	01110011001100	0		16	10001100110011	0
	17	01110011000110	0		17	10001100111001	0
	18	01110011000011	0		18	10001100111100	0
	19	01110001111000	0		19	10001110000111	0
	20	01110001110001	0		20	10001110001110	0
	21	01110001100110	0		21	10001110011001	0
	22	01110001100011	0		22	10001110011100	0
	23	01110000111100	0		23	10001111000011	0
	24	01110000111001	0		24	10001111000110	0
1 (A)	25	01110000110011	0	1 (B)	25	10001111001100	0
	26	01110000011110	0		26	10001111100001	0
	27	01110000001111	0		27	10001111110000	0
	28	01100111110000	0		28	10011000001111	0
	29	01100111100001	0		29	10011000011110	0
	30	01100111001100	0		30	10011000110011	0
	31	01100111000110	0		31	10011000111001	0
	32	01100111000011	0		32	10011000111100	0
	33	01100110011100	0		33	10011001100011	0
	34	01100110011001	0		34	10011001100110	0
	35	01100110001110	0		35	10011001110001	0
	36	01100110000111	0		36	10011001111000	0
	37	01100011111000	0		37	10011100000111	0
	38	01100011110001	0		38	10011100001110	0
	39	01100011100110	0		39	10011100011001	0
	40	01100011100011	0		40	10011100011100	0
	41	01100011001110	0		41	10011100110001	0
	42	01100011000111	0		42	10011100111000	0
	43	01100001111100	0		43	10011110000011	0
	44	01100001111001	0		44	10011110000110	0
	45	01100001110011	0		45	10011110001100	0
	46	01100001100111	0		46	10011110011000	0
	47	01100000111110	0		47	10011111000001	0
	48	01100000011111	0		48	10011111100000	0
	49	01111111000001	2		49	10000011111110	2
	50	01111110011000	2		50	10000110011111	2
	51	01111110001100	2		51	10000111001111	2
	52	01111110000110	2		52	10000111100111	2
	53	01111110000011	2		53	10000111110011	2
	54	01111100111000	2		54	10000111111001	2
	55	01111100110001	2		55	10000111111100	2
	56	01111100011100	2		56	10001100011111	2
	57	01111100011001	2		57	10001100111110	2
	58	01111100001110	2		58	10001110001111	2
	59	01111100000111	2		59	10001110011110	2
	60	01111001111000	2		60	10001111000111	2
	61	01111001110001	2		61	10001111001110	2
	62	01111001100110	2		62	10001111100011	2
	63	01111001100011	2		63	10001111100110	2
	64	01111000111100	2		64	10001111110001	2
	65	01111000111001	2		65	10001111111000	2
	66	01111000110011	2		66	10011000011111	2

Table 17 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
1 (A)	67	01111000011110	2	1 (B)	67	10011000111110	2
	68	01111000001111	2		68	10011001100111	2
	69	01110011111000	2		69	10011001110011	2
	70	01110011110001	2		70	10011001111001	2
	71	01110011100110	2		71	10011001111100	2
	72	01110011100011	2		72	10011100001111	2
	73	01110011001110	2		73	10011100011110	2
	74	01110011000111	2		74	10011100110011	2
	75	01110001111100	2		75	10011100111001	2
	76	01110001111001	2		76	10011100111100	2
	77	01110001110011	2		77	10011110000111	2
	78	01110001100111	2		78	10011110001110	2
	79	01110000111110	2		79	10011110011001	2
	80	01110000011111	2		80	10011110011100	2
	81	01100111111000	2		81	10011111000011	2
	82	01100111110001	2		82	10011111000110	2
	83	01100111100110	2		83	10011111001100	2
	84	01100111100011	2		84	10011111100001	2
	85	01100111001110	2		85	10011111110000	2
	86	01100111000111	2		86	10011111000111	4
	87	01100110011110	2	2 (B)	87	11000011111110	4
	88	01100110001111	2		88	11000110011111	4
	89	01100011111100	2		89	11000111001111	4
	90	01100011111001	2		90	11000111100111	4
	91	01100011110011	2		91	11000111110011	4
	92	01100011100111	2		92	11000111111001	4
	93	01100011001111	2		93	11000111111100	4
	94	01100001111110	2		94	11001100011111	4
	95	01111111001100	4		95	11001100111110	4
	96	01111111000110	4		96	11001110001111	4
	97	01111111000011	4		97	11001110011110	4
	98	01111110011100	4		98	11001111000111	4
	99	01111110011001	4		99	11001111001110	4
	100	01111110001110	4		100	11001111100011	4
	101	01111110000111	4		101	11000001111110	2
	102	01111100111100	4		102	11000011001111	2
	103	01111100111001	4		103	11000011100111	2
	104	01111100110011	4		104	11000011110011	2
	105	01111100011110	4		105	11000011111001	2
	106	01111100001111	4		106	11000011111100	2
	107	01111001111100	4		107	11000110001111	2
	108	01111001111001	4		108	11000110011110	2
	109	01111001110011	4		109	11000111000111	2
	110	01111001100111	4		110	11000111001110	2
	111	01111000111110	4		111	11000111100011	2
	112	01111000011111	4		112	11000111100110	2
	113	01110011111100	4		113	11000111110001	2
	114	01110011111001	4		114	11000111111000	2
	115	01110011110011	4		115	11001100001111	2
	116	01110011100111	4		116	11001100011110	2
	117	01110011001111	4		117	11001100110011	2
	118	01110001111110	4		118	11001100111001	2
	119	01100111111100	4		119	11001100111100	2
	120	01100111111001	4		120	11001110000111	2
	121	01100111110011	4		121	11001110001110	2
	122	01100111100111	4		122	11001110011001	2
	123	01100111001111	4		123	11001110011100	2
	124	01100110011111	4		124	11001111000011	2
	125	01100011111110	4		125	11001111000110	2
	126	01111111000111	6		126	11001111001100	2
	127	01111110001111	6		127	11001111100001	2
	128	01111100011111	6		128	11001111110000	2
2 (A)	129	00111111100000	0		129	11000000011111	0
	130	00111111000001	0		130	11000000111110	0
	131	00111110011000	0		131	11000001100111	0
	132	00111110001100	0		132	11000001110011	0
	133	00111110000110	0		133	11000001111001	0

Table 17 (CDS ≧ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
2 (A)	134	00111110000011	0	2 (B)	134	11000001111100	0
	135	00111100111000	0		135	11000011000111	0
	136	00111100110001	0		136	11000011001110	0
	137	00111100011100	0		137	11000011100011	0
	138	00111100011001	0		138	11000011100110	0
	139	00111100001110	0		139	11000011110001	0
	140	00111100000111	0		140	11000011111000	0
	141	00111001111000	0		141	11000110000111	0
	142	00111001110001	0		142	11000110001110	0
	143	00111001100110	0		143	11000110011001	0
	144	00111001100011	0		144	11000110011100	0
	145	00111000111100	0		145	11000111000011	0
	146	00111000111001	0		146	11000111000110	0
	147	00111000110011	0		147	11000111001100	0
	148	00111000011110	0		148	11000111100001	0
	149	00111000001111	0		149	11000111110000	0
	150	00110011111000	0		150	11001100000111	0
	151	00110011110001	0		151	11001100001110	0
	152	00110011100110	0		152	11001100011001	0
	153	00110011100011	0		153	11001100011100	0
	154	00110011001110	0		154	11001100110001	0
	155	00110011000111	0		155	11001100111000	0
	156	00110001111100	0		156	11001110000011	0
	157	00110001111001	0		157	11001110000110	0
	158	00110001110011	0		158	11001110001100	0
	159	00110001100111	0		159	11001110011000	0
	160	00110000111110	0		160	11001111000001	0
	161	00110000011111	0		161	11001111100000	0
	162	00111111100001	2		162	11001111100110	4
	163	00111111001100	2		163	11001111110001	4
	164	00111111000110	2		164	11001111111000	4
	165	00111111000011	2	3 (B)	165	11100001111110	4
	166	00111110011100	2		166	11100011001111	4
	167	00111110011001	2		167	11100011100111	4
	168	00111110001110	2		168	11100011110011	4
	169	00111110000111	2		169	11100011111001	4
	170	00111100111100	2		170	11100011111100	4
	171	00111100111001	2		171	11100110001111	4
	172	00111100110011	2		172	11100110011110	4
	173	00111100011110	2		173	11100111000111	4
	174	00111100001111	2		174	11100111001110	4
	175	00111001111100	2		175	11100111100011	4
	176	00111001111001	2		176	11100111100110	4
	177	00111001110011	2		177	11100111110001	4
	178	00111001100111	2		178	11100111111000	4
	179	00111000111110	2		179	11100000011111	2
	180	00111000011111	2		180	11100000111110	2
	181	00110011111100	2		181	11100001100111	2
	182	00110011111001	2		182	11100001110011	2
	183	00110011110011	2		183	11100001111001	2
	184	00110011100111	2		184	11100001111100	2
	185	00110011001111	2		185	11100011000111	2
	186	00110001111110	2		186	11100011001110	2
	187	00111111100110	4		187	11100011100011	2
	188	00111111100011	4		188	11100011100110	2
	189	00111111001110	4		189	11100011110001	2
	190	00111111000111	4		190	11100011111000	2
	191	00111110011110	4		191	11100110000111	2
	192	00111110001111	4		192	11100110001110	2
	193	00111100111110	4		193	11100110011001	2
	194	00111100011111	4		194	11100110011100	2
	195	00111001111110	4		195	11100111000011	2
	196	00110011111110	4		196	11100111000110	2
	197	00111111100111	6		197	11100111001100	2
	198	00111111001111	6		198	11100111100001	2
	199	00111110011111	6		199	11100111110000	2

Table 17 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
3 (A)	200	00011111110000	0	3 (B)	200	11100000001111	0
	201	00011111100001	0		201	11100000011110	0
	202	00011111001100	0		202	11100000110011	0
	203	00011111000110	0		203	11100000111001	0
	204	00011111000011	0		204	11100000111100	0
	205	00011110011100	0		205	11100001100011	0
	206	00011110011001	0		206	11100001100110	0
	207	00011110001110	0		207	11100001110001	0
	208	00011110000111	0		208	11100001111000	0
	209	00011100111100	0		209	11100011000011	0
	210	00011100111001	0		210	11100011000110	0
	211	00011100110011	0		211	11100011001100	0
	212	00011100011110	0		212	11100011100001	0
	213	00011100001111	0		213	11100011110000	0
	214	00011001111100	0		214	11100110000011	0
	215	00011001111001	0		215	11100110000110	0
	216	00011001110011	0		216	11100110001100	0
	217	00011001100111	0		217	11100110011000	0
	218	00011000111110	0		218	11100111000001	0
	219	00011000011111	0		219	11100111100000	0
	220	00011111110001	2	4 (B)	220	11110000001111	2
	221	00011111100110	2		221	11110000011110	2
	222	00011111100011	2		222	11110000110011	2
	223	00011111001110	2		223	11110000111001	2
	224	00011111000111	2		224	11110000111100	2
	225	00011110011110	2		225	11110001100011	2
	226	00011110001111	2		226	11110001100110	2
	227	00011100111110	2		227	11110001110001	2
	228	00011100011111	2		228	11110001111000	2
	229	00011001111110	2		229	11110011000011	2
	230	00011111110011	4		230	11110011000110	2
	231	00011111100111	4		231	11110011001100	2
	232	00011111001111	4		232	11110011100001	2
	233	00011110011111	4		233	11110011110000	2
4 (A)	234	00001111111000	0		234	11110000000111	0
	235	00001111110001	0		235	11110000001110	0
	236	00001111100110	0		236	11110000011001	0
	237	00001111100011	0		237	11110000011100	0
	238	00001111001110	0		238	11110000110001	0
	239	00001111000111	0		239	11110000111000	0
	240	00001110011110	0		240	11110001100001	0
	241	00001110001111	0		241	11110001110000	0
	242	00001100111110	0		242	11110011000001	0
	243	00001100011111	0		243	11110011100000	0
	244	00001111111001	2	5 (B)	244	11111000000111	2
	245	00001111110011	2		245	11111000011100	2
	246	00001111100111	2		246	11111000110001	2
	247	00001111001111	2		247	11111000111000	2
	248	00001110011111	2		248	11111001110000	2
5 (A)	249	00000111111100	0		249	11111000000011	0
	250	00000111111001	0		250	11111000000110	0
	251	00000111110011	0		251	11111000001100	0
	252	00000111100111	0		252	11111000011000	0
	253	00000111001111	0		253	11111000110000	0
	254	00000110011111	0		254	11111001100000	0
6 (A)	255	00000011111110	0	6 (B)	255	11111100000001	0

Table 18 (CDS ≤ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	0	01111110000001	0		0	10000001111110	0
	1	01111100110000	0		1	10000011001111	0
	2	01111100011000	0		2	10000011100111	0
	3	01111100001100	0		3	10000011110011	0
	4	01111100000110	0		4	10000011111001	0
	5	01111100000011	0		5	10000011111100	0
	6	01111001110000	0		6	10000110001111	0
	7	01111001100001	0		7	10000110011110	0
	8	01111000111000	0		8	10000111000111	0
	9	01111000110001	0		9	10000111001110	0
	10	01111000011100	0		10	10000111100011	0
	11	01111000011001	0		11	10000111100110	0
	12	01111000001110	0		12	10000111110001	0
	13	01111000000111	0		13	10000111111000	0
	14	01110011110000	0		14	10001100001111	0
	15	01110011100001	0		15	10001100011110	0
	16	01110011001100	0		16	10001100110011	0
	17	01110011000110	0		17	10001100111001	0
	18	01110011000011	0		18	10001100111100	0
	19	01110001111000	0		19	10001110000111	0
	20	01110001110001	0		20	10001110001110	0
	21	01110001100110	0		21	10001110011001	0
	22	01110001100011	0		22	10001110011100	0
	23	01110000111100	0		23	10001111000011	0
	24	01110000111001	0		24	10001111000110	0
	25	01110000110011	0		25	10001111001100	0
1 (C)	26	01110000011110	0	1 (D)	26	10001111100001	0
	27	01110000001111	0		27	10001111110000	0
	28	01100111110000	0		28	10011000001111	0
	29	01100111100001	0		29	10011000011110	0
	30	01100111001100	0		30	10011000110011	0
	31	01100111000110	0		31	10011000111001	0
	32	01100111000011	0		32	10011000111100	0
	33	01100110011100	0		33	10011001100011	0
	34	01100110011001	0		34	10011001100110	0
	35	01100110001110	0		35	10011001110001	0
	36	01100110000111	0		36	10011001111000	0
	37	01100011111000	0		37	10011100000111	0
	38	01100011110001	0		38	10011100001110	0
	39	01100011100110	0		39	10011100011001	0
	40	01100011100011	0		40	10011100011100	0
	41	01100011001110	0		41	10011100110001	0
	42	01100011000111	0		42	10011100111000	0
	43	01100001111100	0		43	10011110000011	0
	44	01100001111001	0		44	10011110000110	0
	45	01100001110011	0		45	10011110001100	0
	46	01100001100111	0		46	10011110011000	0
	47	01100000111110	0		47	10011111000001	0
	48	01100000011111	0		48	10011111100000	0
	49	01111100000001	-2		49	10000000111110	-2
	50	01111001100000	-2		50	10000001100111	-2
	51	01111000110000	-2		51	10000001110011	-2
	52	01111000011000	-2		52	10000001111001	-2
	53	01111000001100	-2		53	10000001111100	-2
	54	01111000000110	-2		54	10000011000111	-2
	55	01111000000011	-2		55	10000011001110	-2
	56	01110011100000	-2		56	10000011100011	-2
	57	01110011000001	-2		57	10000011100110	-2
	58	01110001110000	-2		58	10000011110001	-2
	59	01110001100001	-2		59	10000011111000	-2
	60	01110000111000	-2		60	10000110000111	-2
	61	01110000110001	-2		61	10000110001110	-2
	62	01110000011100	-2		62	10000110011001	-2
	63	01110000011001	-2		63	10000110011100	-2
	64	01110000001110	-2		64	10000111000011	-2
	65	01110000000111	-2		65	10000111000110	-2
	66	01100111100000	-2		66	10000111001100	-2

Table 18 (CDS ≤ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
1 (C)	67	01100111000001	-2	1 (D)	67	10000111100001	-2
	68	01100110011000	-2		68	10000111110000	-2
	69	01100110001100	-2		69	10001100000111	-2
	70	01100110000110	-2		70	10001100001110	-2
	71	01100110000011	-2		71	10001100011001	-2
	72	01100011110000	-2		72	10001100011100	-2
	73	01100011100001	-2		73	10001100110001	-2
	74	01100011001100	-2		74	10001100111000	-2
	75	01100011000110	-2		75	10001110000011	-2
	76	01100011000011	-2		76	10001110000110	-2
	77	01100001111000	-2		77	10001110001100	-2
	78	01100001110001	-2		78	10001110011000	-2
	79	01100001100110	-2		79	10001111000001	-2
	80	01100001100011	-2		80	10001111100000	-2
	81	01100000111100	-2		81	10011000000111	-2
	82	01100000111001	-2		82	10011000001110	-2
	83	01100000110011	-2		83	10011000011001	-2
	84	01100000011110	-2		84	10011000011100	-2
	85	01100000001111	-2		85	10011000110001	-2
	86	01100000111000	-6		86	10011000111000	-2
2 (C)	87	00111100000001	-4		87	10011001100001	-2
	88	00111001100000	-4		88	10011001110000	-2
	89	00111000110000	-4		89	10011100000011	-2
	90	00111000011000	-4		90	10011100000110	-2
	91	00111000001100	-4		91	10011100001100	-2
	92	00111000000110	-4		92	10011100011000	-2
	93	00111000000011	-4		93	10011100110000	-2
	94	00110011100000	-4		94	10011110000001	-2
	95	00110011000001	-4		95	10000000110011	-4
	96	00110001110000	-4		96	10000000111001	-4
	97	00110001100001	-4		97	10000000111100	-4
	98	00110000111000	-4		98	10000001100011	-4
	99	00110000110001	-4		99	10000001100110	-4
	100	00110000011100	-4		100	10000001110001	-4
	101	00111110000001	-2		101	10000001111000	-4
	102	00111100110000	-2		102	10000011000011	-4
	103	00111100011000	-2		103	10000011000110	-4
	104	00111100001100	-2		104	10000011001100	-4
	105	00111100000110	-2		105	10000011100001	-4
	106	00111100000011	-2		106	10000011110000	-4
	107	00111001110000	-2		107	10000110000011	-4
	108	00111001100001	-2		108	10000110000110	-4
	109	00111000111000	-2		109	10000110001100	-4
	110	00111000110001	-2		110	10000110011000	-4
	111	00111000011100	-2		111	10000111000001	-4
	112	00111000011001	-2		112	10000111100000	-4
	113	00111000001110	-2		113	10001100000011	-4
	114	00111000000111	-2		114	10001100000110	-4
	115	00110011110000	-2		115	10001100001100	-4
	116	00110011100001	-2		116	10001100011000	-4
	117	00110011001100	-2		117	10001100110000	-4
	118	00110011000110	-2		118	10001110000001	-4
	119	00110011000011	-2		119	10011000000011	-4
	120	00110001111000	-2		120	10011000000110	-4
	121	00110001110001	-2		121	10011000001100	-4
	122	00110001100110	-2		122	10011000011000	-4
	123	00110001100011	-2		123	10011000110000	-4
	124	00110000111100	-2		124	10011001100000	-4
	125	00110000111001	-2		125	10011100000001	-4
	126	00110000110011	-2		126	10000000111000	-6
	127	00110000011110	-2		127	10000001110000	-6
	128	00110000001111	-2		128	10000011100000	-6
	129	00111111100000	0	2 (D)	129	11000000011111	0
	130	00111111000001	0		130	11000000111110	0
	131	00111110011000	0		131	11000001100111	0
	132	00111110001100	0		132	11000001110011	0

Table 18 (CDS ≤ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	133	00111110000110	0		133	11000001111001	0
	134	00111110000011	0		134	11000001111100	0
	135	00111100111000	0		135	11000011000111	0
	136	00111100110001	0		136	11000011001110	0
	137	00111100011100	0		137	11000011100011	0
	138	00111100011001	0		138	11000011100110	0
	139	00111100001110	0		139	11000011110001	0
	140	00111100000111	0		140	11000011111000	0
	141	00111001111000	0		141	11000110000111	0
	142	00111001110001	0		142	11000110001110	0
	143	00111001100110	0		143	11000110011001	0
	144	00111001100011	0		144	11000110011100	0
	145	00111000111100	0		145	11000111000011	0
	146	00111000111001	0		146	11000111000110	0
	147	00111000110011	0		147	11000111001100	0
2 (C)	148	00111000011110	0		148	11000111100001	0
	149	00111000001111	0		149	11000111110000	0
	150	00110011111000	0		150	11001100000111	0
	151	00110011110001	0		151	11001100001110	0
	152	00110011100110	0		152	11001100011001	0
	153	00110011100011	0		153	11001100011100	0
	154	00110011001110	0		154	11001100110001	0
	155	00110011000111	0		155	11001100111000	0
	156	00110001111100	0		156	11001110000011	0
	157	00110001111001	0	2 (D)	157	11001110000110	0
	158	00110001110011	0		158	11001110001100	0
	159	00110001100111	0		159	11001110011000	0
	160	00110000111110	0		160	11001111000001	0
	161	00110000011111	0		161	11001111100000	0
	162	00110000011001	-4		162	11000000011110	-2
	163	00110000001110	-4		163	11000000110011	-2
	164	00110000000111	-4		164	11000000111001	-2
	165	00011110000001	-4		165	11000000111100	-2
	166	00011100110000	-4		166	11000001100011	-2
	167	00011100011000	-4		167	11000001100110	-2
	168	00011100001100	-4		168	11000001110001	-2
	169	00011100000110	-4		169	11000001111000	-2
	170	00011100000011	-4		170	11000011000011	-2
	171	00011001110000	-4		171	11000011000110	-2
	172	00011001100001	-4		172	11000011001100	-2
	173	00011000111000	-4		173	11000011100001	-2
	174	00011000110001	-4		174	11000011110000	-2
	175	00011000011100	-4		175	11000110000011	-2
	176	00011000011001	-4		176	11000110000110	-2
	177	00011000001110	-4		177	11000110001100	-2
3 (C)	178	00011000000111	-4		178	11000110011000	-2
	179	00011111100000	-2		179	11000111000001	-2
	180	00011111000001	-2		180	11000111100000	-2
	181	00011110011000	-2		181	11001100000011	-2
	182	00011110001100	-2		182	11001100000110	-2
	183	00011110000110	-2		183	11001100001100	-2
	184	00011110000011	-2		184	11001100011000	-2
	185	00011100111000	-2		185	11001100110000	-2
	186	00011100110001	-2		186	11001110000001	-2
	187	00011100011100	-2		187	11000000011001	-4
	188	00011100011001	-2		188	11000000011100	-4
	189	00011100001110	-2		189	11000000110001	-4
	190	00011100000111	-2		190	11000000111000	-4
	191	00011001111000	-2		191	11000001100001	-4
	192	00011001110001	-2		192	11000001110000	-4
	193	00011001100110	-2		193	11000011000001	-4
	194	00011001100011	-2		194	11000011100000	-4
	195	00011000111100	-2		195	11000110000001	-4
	196	00011000111001	-2		196	11001100000001	-4
	197	00011000110011	-2		197	11000000011000	-6
	198	00011000011110	-2		198	11000000110000	-6
	199	00011000001111	-2		199	11000001100000	-6

Table 18 (ÇDS ≤ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
3 (C)	200	00011111110000	0	3 (D)	200	11100000001111	0
	201	00011111100001	0		201	11100000011110	0
	202	00011111001100	0		202	11100000110011	0
	203	00011111000110	0		203	11100000111001	0
	204	00011111000011	0		204	11100000111100	0
	205	00011110011100	0		205	11100001100011	0
	206	00011110011001	0		206	11100001100110	0
	207	00011110001110	0		207	11100001110001	0
	208	00011110000111	0		208	11100001111000	0
	209	00011100111100	0		209	11100011000011	0
	210	00011100111001	0		210	11100011000110	0
	211	00011100110011	0		211	11100011001100	0
	212	00011100011110	0		212	11100011100001	0
	213	00011100001111	0		213	11100011110000	0
	214	00011001111100	0		214	11100110000011	0
	215	00011001111001	0		215	11100110000110	0
	216	00011001110011	0		216	11100110001100	0
	217	00011001100111	0		217	11100110011000	0
	218	00011000111110	0		218	11100111000001	0
	219	00011000011111	0		219	11100111100000	0
4 (C)	220	00001111110000	-2		220	11100000001110	-2
	221	00001111100001	-2		221	1110000Q011001	-2
	222	00001111001100	-2		222	11100000011100	-2
	223	00001111000110	-2		223	11100000110001	-2
	224	00001111000011	-2		224	11100000111000	-2
	225	00001110011100	-2		225	11100001100001	-2
	226	00001110011001	-2		226	11100001110000	-2
	227	00001110001110	-2		227	11100011000001	-2
	228	00001110000111	-2		228	11100011100000	-2
	229	00001100111100	-2		229	11100110000001	-2
	230	00001100111001	-2		230	11100000001100	-4
	231	00001100110011	-2		231	11100000011000	-4
	232	00001100011110	-2		232	11100000110000	-4
	233	00001100001111	-2		233	11100001100000	-4
	234	00001111111000	0	4 (D)	234	11110000000111	0
	235	00001111110001	0		235	11110000001110	0
	236	00001111100110	0		236	11110000011001	0
	237	00001111100011	0		237	11110000011100	0
	238	00001111001110	0		238	11110000110001	0
	239	00001111000111	0		239	11110000111000	0
	240	00001110011110	0		240	11110001100001	0
	241	00001110001111	0		241	11110001110000	0
	242	00001100111110	0		242	111T0011000001	0
	243	00001100011111	0		243	11110011100000	0
5 (C)	244	00000111111000	-2		244	11110000000110	-2
	245	00000111100011	-2		245	11110000001100	-2
	246	00000111001110	-2		246	11110000011000	-2
	247	00000111000111	-2		247	11110000110000	-2
	248	00000110001111	-2		248	11110001100000	-2
	249	00000111111100	0	5 (D)	249	11111000000011	0
	250	00000111111001	0		250	11111000000110	0
	251	00000111110011	0		251	11111000001100	0
	252	00000111100111	0		252	11111000011000	0
	253	00000111001111	0		253	11111000110000	0
	254	00000110011111	0		254	11111001100000	0
6 (C)	255	00000011111110	0	6 (D)	255	11111100000001	0

Types of the modulation codes that are allowed to take place according to the end pattern of the preceding modulation code are shown in Table 19.

TABLE 19

		Consecutive number of "0" bits at the beginning of modulation code						Consecutive number of "1" bits at the beginning of modulation code					
End pattern of the preceding modulation codes	CDS≧0	1 (A)	2 (A)	3 (A)	4 (A)	5 (A)	6 (A)	1 (B)	2 (B)	3 (B)	4 (B)	5 (B)	6 (B)
	CDS≦0	1 (C)	2 (C)	3 (C)	4 (C)	5 (C)	6 (C)	1 (D)	2 (D)	3 (D)	4 (D)	5 (D)	6 (D)
	110	o	o	o	o	o	o						
	1100	o	o	o	o	o			o	o	o	o	o
	11000	o	o	o	o				o	o	o	o	o
	110000	o	o	o					o	o	o	o	o
	1100000	o	o						o	o	o	o	o
	001							o	o	o	o	o	o
	0011		o	o	o	o	o	o	o	o	o	o	
	00111		o	o	o	o	o	o	o	o	o		
	001111		o	o	o	o	o	o	o	o			
	0011111		o	o	o	o	o	o	o				

"o" mark indicates that the modulation codes are allowed.

For example, when the end pattern of the preceding modulation code is "...11000", and the end DSV of the preceding modulation code is -4, the modulation codes of classes 1(A), 2(A), 3(A), 4(A), 2(B), 3(B), 4(B), 5(B) and (6B) in Table 17 can take place as a current modulation code.

In this case, suppose that the current 8-bit data is "166". Then, one of the two possible modulation codes "00111110011100" (CDS = 2; 2(A)), and "11100011001111" (CDS = 4; 2(B)) is selected: the end DSV at the end of the preceding modulation code and the CDS of the current modulation code are added so as to obtain the end DSV at the end of the current modulation code; the modulation code which will give less DSV is selected, that is, the modulation code "11100011001111" (CDS = 4) is selected. The resultant DSV is 0 and it indicates that the direct current component is removed.

Fig. 3A shows the CNR (carrier-to-noise ratio) characteristics when a sine wave recorded on magnetic tape is reproduced, Fig. 3B shows the power spectrum at the output terminal of the modulator of the embodiment when random 8-bit data are inputted to the modulator, and Fig. 3C shows the power spectrum of the scrambled NRZ at the output terminal of the scrambled NRZ modulator when random 8-bit data are inputted to the scrambled NRZ modulator.

As described above, the embodiment restricts the number of consecutive identical bits in a stream of modulation codes to 2 - 7. As a result, the minimum magnetization transition width is 1.14T (= (2 × 8)T/14, where T is the bit period of the 8-bit data), the maximum magnetization transition width is 4.00T (= (7 × 8)-T/14), DR is 1.14 (=(2 × 8)/14), and the ratio of the maximum magnetization transition width to the minimum magnetization transition width is 3.5. Consequently, the bit error rate of the magnetic recording is reduced, and the high-density recording becomes possible. In addition, azimuth recording and high quality over-writing become possible.

Furthermore, the embodiment restricts the absolute value of CDS of the modulation codes equal to or less than 6, allocates up to 4 modulation codes to each 8-bit data according to the DSV at the end of the preceding modulation code and the end pattern of the preceding code, and selects the modulation code the DSV of which gives the least absolute value. As a result, the maximum value of the absolute value of the end DSV can be restricted within 4. Thus, the direct current component can be effectively removed, and hence, the transmission of the modulation codes becomes possible by using a rotary transformer that does not pass the direct current component.

Although specific embodiments of a digital modulation method in accordance with the present invention have been disclosed, it is not intended that the invention be restricted to either the specific configurations or the uses disclosed herein. Modifications may be made in a manner obvious to those skilled in the art. Accordingly, it is intended that the invention be limited only by the scope of the appended claims.

A digital modulation method for modulating 8-bit digital data into 14-bit digital modulation codes. The number of consecutive identical bits in a series of 14-bit digital modulation codes is restricted to 2 - 7. The absolute value of DSV at the end of each 14-bit digital modulation code is restricted to 2 or less, and the absolute value of DSV at each bit of any 14-bit digital modulation codes is limited to 7 or less. The direct current component of the 14-bit modulation codes can be effectively reduced.

Claims

1. A digital modulation method for converting 8-bit digital data into 14-bit digital modulation codes, said digital modulation method characterized by comprising:

step 1 for selecting up to four 14-bit digital modulation codes for each 8-bit digital data, said 14-bit digital modulation code is selected by the procedures of

(a) selecting among the 2^{14} 14-bit digital codes, a digital code the numbers of consecutive identical bits in which are 5 or less in the first 6 bits, 2 - 7 from the second bit to 13th bit, and 6 or less in the last 7 bits, the absolute value of CDS (code word digital sum) of the selected digital code being 4 or less, and repeating this selecting procedure,

(b) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is 0, and pairing the selected 14-bit digital code with the reversal code thereof to make the 2 digital codes one group, or selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "1", and the value of CDS of which is +2 or +4, combining the selected 14-bit digital codes with the reversal codes thereof, and further combining the two 14-bit digital codes with a pair of 14-bit digital codes selected at the above procedure to make the 4 digital codes one group, and repeating this selecting procedure,

(c) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is +2, and another digital code the first bit of which is "1", and the value of CDS of which is +2 or +4, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure,

(d) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is +4, and another digital code the first bit of which is "1", and the value of CDS of which is +2, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure, and

(e) selecting 256 groups among the groups formed in the above procedures as the 14-bit digital modulation codes;

step 2 for selecting one group of 14-bit digital modulation codes among the 256 groups of the 14-bit

digital modulation codes, the selected group corresponding to inputted 8-bit digital data;

step 3 for further selecting one or more 14-bit digital modulation codes in the selected group at step 2, each of the 14-bit digital modulation codes satisfying the requirement that the number of consecutive identical bits at the joint portion of the preceding 14-bit digital modulation code already selected and the 14-bit digital modulation code to be selected is 2 - 7; and

step 4 for further selecting one 14-bit digital modulation code among the selected modulation codes at step 3 so that said one 14-bit digital modulation code satisfies the requirement that the absolute value of bit DSV (Digital Sum Value) for each bit in the modulation code is equal to or less than 7.

2. A digital modulation method as claimed in claim 1, characterized in that said step 3 comprises the procedures of:

selecting any one of the digital modulation codes the first bits of which are "01", "001", "0001", "00001", and "000001" when the preceding digital modulation code that has already been selected terminates with "10";

selecting any one of the digital modulation codes the first bits of which are "10", "110", "1110", "11110", and "111110" when the preceding digital modulation code that has already been selected terminates with "01";

selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", "01", "001", "0001", "00001", and "000001" when the preceding digital modulation code that has already been selected terminates with "100";

selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", "000001", "10", "110", "1110", "11110", and "111110" when the preceding digital modulation code that has already been selected terminates with "011";

selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", "01", "001", "0001", and "00001" when the preceding digital modulation code that has already been selected terminates with "1000";

selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", "000001", "10", "110", "1110", and "11110" when the preceding digital modulation code that has already been selected terminates with "0111";

selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", "01", "001", and "0001" when the preceding digital modulation code that has already been selected terminates with "10000";

selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", "000001", "10", "110", and "1110" when the preceding digital modulation code that has already been selected terminates with "01111";

selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", "01", and "001" when the preceding digital modulation code that has already been selected terminates with "100000";

selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", "000001", "10", and "110" when the preceding digital modulation code that has already been selected terminates with "011111";

selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", and "01" when the preceding digital modulation code that has already been selected terminates with "1000000"; and

selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", "000001", and "10" when the preceding digital modulation code that has already been selected terminates with "0111111";

3. A digital modulation method as claimed in claim 1, characterized in that said step 4 comprises the procedures of:

selecting any one of the digital modulation codes the CDS of which are 0, -2 and -4, when the DSV at the end of the preceding 14-bit digital modulation code that has already been selected is +2;

selecting any one of the digital modulation codes the CDS of which are +2, 0 and -2, when the DSV at the end of the preceding 14-bit digital modulation code that has already been selected is 0; and

selecting any one of the digital modulation codes the CDS of which are +4, +2, and 0 when the DSV at the end of the preceding 14-bit digital modulation code that has already been selected is -2;

4. A digital modulation method as claimed in claim 1, characterized in that said digital modulation codes obtained at step 1 are the codes described in the following Tables 4 and 5, or the codes obtained by substituting a part of Table 4 by the following Table 12, or the codes obtained by substituting a part of Table 5 by the following Table 13.

Table 4 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	0	01111110000001	0		0	10000001111110	0
	1	01111100110000	0		1	10000011001111	0
	2	01111100011000	0		2	10000011100111	0
	3	01111100001100	0		3	10000011110011	0
	4	01111100000110	0		4	10000011111001	0
	5	01111100000011	0		5	10000011111100	0
	6	01111001110000	0		6	10000110001111	0
	7	01111001100001	0		7	10000110011110	0
	8	01111000111000	0		8	10000111000111	0
	9	01111000110001	0		9	10000111001110	0
	10	01111000011100	0		10	10000111100011	0
	11	01111000011001	0		11	10000111100110	0
	12	01111000001110	0		12	10000111110001	0
	13	01111000000111	0		13	10000111111000	0
	14	01110011110000	0		14	10001100001111	0
	15	01110011100001	0		15	10001100011110	0
	16	01110011001100	0		16	10001100110011	0
	17	01110011000110	0		17	10001100111001	0
	18	01110011000011	0		18	10001100111100	0
	19	01110001111000	0		19	10001110000111	0
	20	01110001110001	0		20	10001110001110	0
	21	01110001100110	0		21	10001110011001	0
	22	01110001100011	0		22	10001110011100	0
	23	01110000111100	0		23	10001111000011	0
	24	01110000111001	0		24	10001111000110	0
	25	01110000110011	0		25	10001111001100	0
	26	01110000011110	0		26	10001111100001	0
	27	01110000001111	0		27	10001111110000	0
	28	01100111110000	0		28	10011000001111	0
	29	01100111100001	0		29	10011000011110	0
	30	01100111001100	0		30	10011000110011	0
	31	01100111000110	0		31	10011000111001	0
	32	01100111000011	0		32	10011000111100	0
	33	01100110011100	0		33	10011001100011	0
1(A)	34	01100110011001	0	1(B)	34	10011001100110	0
	35	01100110001110	0		35	10011001110001	0
	36	01100110000111	0		36	10011001111000	0
	37	01100011111000	0		37	10011100000111	0
	38	01100011110001	0		38	10011100001110	0
	39	01100011100110	0		39	10011100011001	0
	40	01100011100011	0		40	10011100011100	0
	41	01100011001110	0		41	10011100110001	0
	42	01100011000111	0		42	10011100111000	0
	43	01100001111100	0		43	10011110000011	0
	44	01100001111001	0		44	10011110000110	0
	45	01100001110011	0		45	10011110001100	0
	46	01100001100111	0		46	10011110011000	0
	47	01100000111110	0		47	10011111000001	0
	48	01100000011111	0		48	10011111100000	0
	49	01111111001100	4		49	10000011111110	2
	50	01111111000110	4		50	10000110011111	2
	51	01111111000011	4		51	10000111001111	2
	52	01111110011100	4		52	10000111100111	2
	53	01111110011001	4		53	10000111110011	2
	54	01111110001110	4		54	10000111111001	2
	55	01111110000111	4		55	10000111111100	2
	56	01111100111100	4		56	10001100011111	2
	57	01111100111001	4		57	10001100111110	2
	58	01111100110011	4		58	10001110001111	2
	59	01111100011110	4		59	10001110011110	2
	60	01111100001111	4		60	10001111000111	2
	61	01111001111100	4		61	10001111001110	2
	62	01111001111001	4		62	10001111100011	2
	63	01111001110011	4		63	10001111100110	2

Table 4 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
1(A)	64	01111001100111	4	1(B)	64	10001111110001	2
	65	01111000111110	4		65	10001111111000	2
	66	01111000011111	4		66	10011000011111	2
	67	01110011111100	4		67	10011000111110	2
	68	01110011111001	4		68	10011001100111	2
	69	01110011110011	4		69	10011001110011	2
	70	01110011100111	4		70	10011001111001	2
	71	01110011001111	4		71	10011001111100	2
	72	01110001111110	4		72	10011100001111	2
	73	01110000111111	4		73	10011100011110	2
	74	01100111111100	4		74	10011100110011	2
	75	01100111111001	4		75	10011100111001	2
	76	01100111110011	4		76	10011100111100	2
	77	01100111100111	4		77	10011110000111	2
	78	01100111001111	4		78	10011110001110	2
	79	01100110011111	4		79	10011110011001	2
	80	01100011111110	4		80	10011110011100	2
	81	01111111000001	2		81	10011111000011	2
	82	01111110011000	2		82	10011111000110	2
	83	01111110001100	2		83	10011111001100	2
	84	01111110000110	2		84	10011111100001	2
	85	01111110000011	2		85	10011111110000	2
	86	01111100111000	2		86	10001111001111	4
	87	01111100110001	2		87	10001111100111	4
	88	01111100011100	2		88	10001111110011	4
	89	01111100011001	2		89	10011001111110	4
	90	01111100001110	2		90	10011100111110	4
	91	01111100000111	2		91	10011110001111	4
	92	01111001111000	2		92	10011110011110	4
	93	01111001110001	2		93	10011111000111	4
	94	01111001100110	2		94	10011111001110	4
	95	01111001100011	2		95	10011111100011	4
	96	01111000111100	2		96	10011111100110	4
	97	01111000111001	2	2(B)	97	11000111100111	4
	98	01111000110011	2		98	11000111110011	4
	99	01111000011110	2		99	11000000111111	2
	100	01111000001111	2		100	11000001111110	2
	101	01110011111000	2		101	11000011001111	2
	102	01110011110001	2		102	11000011100111	2
	103	01110011100110	2		103	11000011110011	2
	104	01110011100011	2		104	11000011111001	2
	105	01110011001110	2		105	11000011111100	2
	106	01110011000111	2		106	11000110001111	2
	107	01110001111100	2		107	11000110011110	2
	108	01110001111001	2		108	11000111000111	2
	109	01110001110011	2		109	11000111001110	2
	110	01110001100111	2		110	11000111100011	2
	111	01110000111110	2		111	11000111100110	2
	112	01110000011111	2		112	11000111110001	2
	113	01100111111000	2		113	11000111111000	2
	114	01100111110001	2		114	11001100001111	2
	115	01100111100110	2		115	11001100011110	2
	116	01100111100011	2		116	11001100110011	2
	117	01100111001110	2		117	11001100111001	2
	118	01100111000111	2		118	11001100111100	2
	119	01100110011110	2		119	11001110000111	2
	120	01100110001111	2		120	11001110001110	2
	121	01100011111100	2		121	11001110011001	2
	122	01100011111001	2		122	11001110011100	2
	123	01100011110011	2		123	11001111000011	2
	124	01100011100111	2		124	11001111000110	2
	125	01100011001111	2		125	11001111001100	2
	126	01100001111110	2		126	11001111100001	2
	127	01100000111111	2		127	11001111110000	2

Table 4 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	128	00111111100000	0		128	11000000011111	0
	129	00111111000001	0		129	11000000111110	0
	130	00111110011000	0		130	11000001100111	0
	131	00111110001100	0		131	11000001110011	0
	132	00111110000110	0		132	11000001111001	0
	133	00111110000011	0		133	11000001111100	0
	134	00111100111000	0		134	11000011000111	0
	135	00111100110001	0		135	11000011001110	0
	136	00111100011100	0		136	11000011100011	0
	137	00111100011001	0		137	11000011100110	0
	138	00111100001110	0		138	11000011110001	0
	139	00111100000111	0		139	11000011111000	0
	140	00111001111000	0		140	11000110000111	0
	141	00111001110001	0		141	11000110001110	0
	142	00111001100110	0		142	11000110011001	0
	143	00111001100011	0	2(B)	143	11000110011100	0
	144	00111000111100	0		144	11000111000011	0
	145	00111000111001	0		145	11000111000110	0
	146	00111000110011	0		146	11000111001100	0
	147	00111000011110	0		147	11000111100001	0
	148	00111000001111	0		148	11000111110000	0
	149	00110011111000	0		149	11001100000111	0
	150	00110011110001	0		150	11001100001110	0
	151	00110011100110	0		151	11001100011001	0
	152	00110011100011	0		152	11001100011100	0
	153	00110011001110	0		153	11001100110001	0
	154	00110011000111	0		154	11001100111000	0
	155	00110001111100	0		155	11001110000011	0
	156	00110001111001	0		156	11001110000110	0
	157	00110001110011	0		157	11001110001100	0
	158	00110001100111	0		158	11001110011000	0
	159	00110000111110	0		159	11001111000001	0
	160	00110000011111	0		160	11001111100000	0
	161	00111111100001	2		161	11001100111110	4
2(A)	162	00111111001100	2		162	11001110011110	4
	163	00111111000110	2		163	11001111000111	4
	164	00111111000011	2		164	11001111001110	4
	165	00111110011100	2		165	11001111100011	4
	166	00111110011001	2		166	11001111100110	4
	167	00111110001110	2		167	11100000111110	4
	168	00111110000111	2		168	11100011100111	4
	169	00111100111100	2		169	11100011110011	4
	170	00111100111001	2		170	11100011111100	4
	171	00111100110011	2		171	11100110011110	4
	172	00111100011110	2		172	11100111000111	4
	173	00111100001111	2	3(B)	173	11100111001110	4
	174	00111001111100	2		174	11100111100011	4
	175	00111001111001	2		175	11100111100110	4
	176	00111001110011	2		176	11100111111000	4
	177	00111001100111	2		177	11100000011111	2
	178	00111000111110	2		178	11100000111110	2
	179	00111000011111	2		179	11100001100111	2
	180	00110011111100	2		180	11100001110011	2
	181	00110011111001	2		181	11100001111001	2
	182	00110011110011	2		182	11100001111100	2
	183	00110011100111	2		183	11100011000111	2
	184	00110011001111	2		184	11100011001110	2
	185	00110001111110	2		185	11100011100011	2
	186	00110000111111	2		186	11100011100110	2
	187	00111111100110	4		187	11100011110001	2
	188	00111111100011	4		188	11100011111000	2
	189	00111111001110	4		189	11100110000111	2
	190	00111111000111	4		190	11100110001110	2
	191	00111110011110	4		191	11100110011001	2

Table 4 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
2(A)	192	00111110001111	4	3(B)	192	11100110011100	2
	193	00111100111110	4		193	11100111000011	2
	194	00111100011111	4		194	11100111000110	2
	195	00111001111110	4		195	11100111001100	2
	196	00111000111111	4		196	11100111100001	2
	197	00110011111110	4		197	11100111110000	2
3(A)	198	00011111110000	0		198	11100000001111	0
	199	00011111100001	0		199	11100000011110	0
	200	00011111001100	0		200	11100000110011	0
	201	00011111000110	0		201	11100000111001	0
	202	00011111000011	0		202	11100000111100	0
	203	00011110011100	0		203	11100001100011	0
	204	00011110011001	0		204	11100001100110	0
	205	00011110001110	0		205	11100001110001	0
	206	00011110000111	0		206	11100001111000	0
	207	00011100111100	0		207	11100011000011	0
	208	00011100111001	0		208	11100011000110	0
	209	00011100110011	0		209	11100011001100	0
	210	00011100011110	0		210	11100011100001	0
	211	00011100001111	0		211	11100011110000	0
	212	00011001111100	0		212	11100110000011	0
	213	00011001111001	0		213	11100110000110	0
	214	00011001110011	0		214	11100110001100	0
	215	00011001100111	0		215	11100110011000	0
	216	00011000111110	0		216	11100111000001	0
	217	00011000011111	0		217	11100111100000	0
	218	00011111110001	2	4(B)	218	11110001111100	4
	219	00011111100110	2		219	11110011111000	4
	220	00011111100011	2		220	11110000001111	2
	221	00011111001110	2		221	11110000011110	2
	222	00011111000111	2		222	11110000110011	2
	223	00011110011110	2		223	11110000111001	2
	224	00011110001111	2		224	11110000111100	2
	225	00011100111110	2		225	11110001100011	2
	226	00011100011111	2		226	11110001100110	2
	227	00011001111110	2		227	11110001110001	2
	228	00011000111111	2		228	11110001111000	2
	229	00011111110011	4		229	11110011000011	2
	230	00011111100111	4		230	11110011000110	2
	231	00011111001111	4		231	11110011001100	2
	232	00011110011111	4		232	11110011100001	2
	233	00011100111111	4		233	11110011110000	2
4(A)	234	00001111111000	0		234	11110000000111	0
	235	00001111110001	0		235	11110000001110	0
	236	00001111100110	0		236	11110000011001	0
	237	00001111100011	0		237	11110000011100	0
	238	00001111001110	0		238	11110000110001	0
	239	00001111000111	0		239	11110000111000	0
	240	00001110011110	0		240	11110001100001	0
	241	00001110001111	0		241	11110001110000	0
	242	00001100111110	0		242	11110011000001	0
	243	00001100011111	0		243	11110011100000	0
	244	00001111111001	2	5(B)	244	11111000000111	2
	245	00001111110011	2		245	11111000001110	2
	246	00001111100111	2		246	11111000011001	2
	247	00001111001111	2		247	11111000011100	2
	248	00001110011111	2		248	11111000111000	2
	249	00001100111111	2		249	11111001110000	2
5(A)	250	00000111111100	0		250	11111000000011	0
	251	00000111111001	0		251	11111000000110	0
	252	00000111110011	0		252	11111000001100	0
	253	00000111100111	0		253	11111000011000	0
	254	00000111001111	0		254	11111000110000	0
	255	00000110011111	0		255	11111001100000	0

Table 5 (CDS ≦ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	0	01111110000001	0		0	10000001111110	0
	1	01111100110000	0		1	10000011001111	0
	2	01111100011000	0		2	10000011100111	0
	3	01111100001100	0		3	10000011110011	0
	4	01111100000110	0		4	10000011111001	0
	5	01111100000011	0		5	10000011111100	0
	6	01111001110000	0		6	10000110001111	0
	7	01111001100001	0		7	10000110011110	0
	8	01111000111000	0		8	10000111000111	0
	9	01111000110001	0		9	10000111001110	0
	10	01111000011100	0		10	10000111100011	0
	11	01111000011001	0		11	10000111100110	0
	12	01111000001110	0		12	10000111110001	0
	13	01111000000111	0		13	10000111111000	0
	14	01110011110000	0		14	10001100001111	0
	15	01110011100001	0		15	10001100011110	0
	16	01110011001100	0		16	10001100110011	0
	17	01110011000110	0		17	10001100111001	0
	18	01110011000011	0		18	10001100111100	0
	19	01110001111000	0		19	10001110000111	0
	20	01110001110001	0		20	10001110001110	0
	21	01110001100110	0		21	10001110011001	0
	22	01110001100011	0		22	10001110011100	0
	23	01110000111100	0		23	10001111000011	0
	24	01110000111001	0		24	10001111000110	0
	25	01110000110011	0		25	10001111001100	0
	26	01110000011110	0		26	10001111100001	0
	27	01110000001111	0		27	10001111110000	0
	28	01100111110000	0		28	10011000001111	0
	29	01100111100001	0		29	10011000011110	0
	30	01100111001100	0		30	10011000110011	0
	31	01100111000110	0		31	10011000111001	0
	32	01100111000011	0		32	10011000111100	0
	33	01100110011100	0		33	10011001100011	0
1(C)	34	01100110011001	0	1(D)	34	10011001100110	0
	35	01100110001110	0		35	10011001110001	0
	36	01100110000111	0		36	10011001111000	0
	37	01100011111000	0		37	10011100000111	0
	38	01100011110001	0		38	10011100001110	0
	39	01100011100110	0		39	10011100011001	0
	40	01100011100011	0		40	10011100011100	0
	41	01100011001110	0		41	10011100110001	0
	42	01100011000111	0		42	10011100111000	0
	43	01100001111100	0		43	10011110000011	0
	44	01100001111001	0		44	10011110000110	0
	45	01100001110011	0		45	10011110001100	0
	46	01100001100111	0		46	10011110011000	0
	47	01100000111110	0		47	10011111000001	0
	48	01100000011111	0		48	10011111100000	0
	49	01111100000001	-2		49	10000000110011	-4
	50	01111001100000	-2		50	10000000111001	-4
	51	01111000110000	-2		51	10000000111100	-4
	52	01111000011000	-2		52	10000001100011	-4
	53	01111000001100	-2		53	10000001100110	-4
	54	01111000000110	-2		54	10000001110001	-4
	55	01111000000011	-2		55	10000001111000	-4
	56	01110011100000	-2		56	10000011000011	-4
	57	01110011000001	-2		57	10000011000110	-4
	58	01110001110000	-2		58	10000011001100	-4
	59	01110001100001	-2		59	10000011100001	-4
	60	01110000111000	-2		60	10000011110000	-4
	61	01110000110001	-2		61	10000110000011	-4
	62	01110000011100	-2		62	10000110000110	-4
	63	01110000011001	-2		63	10000110001100	-4

Table 5 (CDS ≤ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	64	01110000001110	-2		64	10000110011000	-4
	65	01110000000111	-2		65	10000111000001	-4
	66	01100111100000	-2		66	10000111100000	-4
	67	01100111000001	-2		67	10001100000011	-4
	68	01100110011000	-2		68	10001100000110	-4
	69	01100110001100	-2		69	10001100001100	-4
	70	01100110000110	-2		70	10001100011000	-4
	71	01100110000011	-2		71	10001100110000	-4
	72	01100011110000	-2		72	10001110000001	-4
	73	01100011100001	-2		73	10001111000000	-4
	74	01100011001100	-2		74	10011000000011	-4
	75	01100011000110	-2		75	10011000000110	-4
	76	01100011000011	-2		76	10011000001100	-4
	77	01100001111000	-2		77	10011000011000	-4
	78	01100001110001	-2		78	10011000110000	-4
1(C)	79	01100001100110	-2		79	10011001100000	-4
	80	01100001100011	-2		80	10011100000001	-4
	81	01100000111100	-2		81	10000000111110	-2
	82	01100000111001	-2		82	10000001100111	-2
	83	01100000110011	-2		83	10000001110011	-2
	84	01100000011110	-2		84	10000001111001	-2
	85	01100000001111	-2		85	10000001111100	-2
	86	01110000110000	-4		86	10000011000111	-2
	87	01110000011000	-4		87	10000011001110	-2
	88	01110000001100	-4		88	10000011100011	-2
	89	01100110000001	-4		89	10000011100110	-2
	90	01100011000001	-4		90	10000011110001	-2
	91	01100001110000	-4		91	10000011111000	-2
	92	01100001100001	-4		92	10000110000111	-2
	93	01100000111000	-4		93	10000110001110	-2
	94	01100000110001	-4		94	10000110011001	-2
	95	01100000011100	-4		95	10000110011100	-2
	96	01100000011001	-4		96	10000111000011	-2
	97	00111000011000	-4		97	10000111000110	-2
	98	00111000001100	-4	1(D)	98	10000111001100	-2
	99	00111111000000	-2		99	10000111100001	-2
	100	00111110000001	-2		100	10000111110000	-2
	101	00111100110000	-2		101	10001100000111	-2
	102	00111100011000	-2		102	10001100001110	-2
	103	00111100001100	-2		103	10001100011001	-2
	104	00111100000110	-2		104	10001100011100	-2
	105	00111100000011	-2		105	10001100110001	-2
	106	00111001110000	-2		106	10001100111000	-2
	107	00111001100001	-2		107	10001110000011	-2
	108	00111000111000	-2		108	10001110000110	-2
	109	00111000110001	-2		109	10001110001100	-2
	110	00111000011100	-2		110	10001110011000	-2
2(C)	111	00111000011001	-2		111	10001111000001	-2
	112	00111000001110	-2		112	10001111100000	-2
	113	00111000000111	-2		113	10011000000111	-2
	114	00110011110000	-2		114	10011000001110	-2
	115	00110011100001	-2		115	10011000011001	-2
	116	00110011001100	-2		116	10011000011100	-2
	117	00110011000110	-2		117	10011000110001	-2
	118	00110011000011	-2		118	10011000111000	-2
	119	00110001111000	-2		119	10011001100001	-2
	120	00110001110001	-2		120	10011001110000	-2
	121	00110001100110	-2		121	10011100000011	-2
	122	00110001100011	-2		122	10011100000110	-2
	123	00110000111100	-2		123	10011100001100	-2
	124	00110000111001	-2		124	10011100011000	-2
	125	00110000110011	-2		125	10011100110000	-2
	126	00110000011110	-2		126	10011110000001	-2
	127	00110000001111	-2		127	10011111000000	-2

Table 5 (CDS ≦ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
2(C)	128	00111111100000	0	2(D)	128	11000000011111	0
	129	00111111000001	0		129	11000000111110	0
	130	00111110011000	0		130	11000001100111	0
	131	00111110001100	0		131	11000001110011	0
	132	00111110000110	0		132	11000001111001	0
	133	00111110000011	0		133	11000001111100	0
	134	00111100111000	0		134	11000011000111	0
	135	00111100110001	0		135	11000011001110	0
	136	00111100011100	0		136	11000011100011	0
	137	00111100011001	0		137	11000011100110	0
	138	00111100001110	0		138	11000011110001	0
	139	00111100000111	0		139	11000011111000	0
	140	00111001111000	0		140	11000110000111	0
	141	00111001110001	0		141	11000110001110	0
	142	00111001100110	0		142	11000110011001	0
	143	00111001100011	0		143	11000110011100	0
	144	00111000111100	0		144	11000111000011	0
	145	00111000111001	0		145	11000111000110	0
	146	00111000110011	0		146	11000111001100	0
	147	00111000011110	0		147	11000111100001	0
	148	00111000001111	0		148	11000111110000	0
	149	00110011111000	0		149	11001100000111	0
	150	00110011110001	0		150	11001100001110	0
	151	00110011100110	0		151	11001100011001	0
	152	00110011100011	0		152	11001100011100	0
	153	00110011001110	0		153	11001100110001	0
	154	00110011000111	0		154	11001100111000	0
	155	00110001111100	0		155	11001110000011	0
	156	00110001111001	0		156	11001110000110	0
	157	00110001110011	0		157	11001110001100	0
	158	00110001100111	0		158	11001110011000	0
	159	00110000111110	0		159	11001111000001	0
	160	00110000011111	0		160	11001111100000	0
	161	00110011000001	-4		161	11000000011110	-2
	162	00110001100001	-4		162	11000000110011	-2
	163	00110000111000	-4		163	11000000111001	-2
	164	00110000110001	-4		164	11000000111100	-2
	165	00110000011100	-4		165	11000001100011	-2
	166	00110000011001	-4		166	11000001100110	-2
3(C)	167	00011110000001	-4		167	11000001110001	-2
	168	00011100011000	-4		168	11000001111000	-2
	169	00011100001100	-4		169	11000011000011	-2
	170	00011100000011	-4		170	11000011000110	-2
	171	00011001100001	-4		171	11000011001100	-2
	172	00011000111000	-4		172	11000011100001	-2
	173	00011000110001	-4		173	11000011110000	-2
	174	00011000011100	-4		174	11000110000011	-2
	175	00011000011001	-4		175	11000110000110	-2
	176	00011000000111	-4		176	11000110001100	-2
	177	00011111100000	-2		177	11000110011000	-2
	178	00011111000001	-2		178	11000111000001	-2
	179	00011110011000	-2		179	11000111100000	-2
	180	00011110001100	-2		180	11001100000011	-2
	181	00011110000110	-2		181	11001100000110	-2
	182	00011110000011	-2		182	11001100001100	-2
	183	00011100111000	-2		183	11001100011000	-2
	184	00011100110001	-2		184	11001100110000	-2
	185	00011100011100	-2		185	11001110000001	-2
	186	00011100011001	-2		186	11001111000000	-2
	187	00011100001110	-2		187	11000000011001	-4
	188	00011100000111	-2		188	11000000011100	-4
	189	00011001111000	-2		189	11000000110001	-4
	190	00011001110001	-2		190	11000000111000	-4
	191	00011001100110	-2		191	11000001100001	-4

Table 5 (CDS ≦ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
3(C)	192	00011001100011	-2	2(D)	192	11000001110000	-4
	193	00011000111100	-2		193	11000011000001	-4
	194	00011000111001	-2		194	11000011100000	-4
	195	00011000110011	-2		195	11000110000001	-4
	196	00011000011110	-2		196	11000111000000	-4
	197	00011000001111	-2		197	11001100000001	-4
	198	00011111110000	0	3(D)	198	11100000001111	0
	199	00011111100001	0		199	11100000011110	0
	200	00011111001100	0		200	11100000110011	0
	201	00011111000110	0		201	11100000111001	0
	202	00011111000011	0		202	11100000111100	0
	203	00011110011100	0		203	11100001100011	0
	204	00011110011001	0		204	11100001100110	0
	205	00011110001110	0		205	11100001110001	0
	206	00011110000111	0		206	11100001111000	0
	207	00011100111100	0		207	11100011000011	0
	208	00011100111001	0		208	11100011000110	0
	209	00011100110011	0		209	11100011001100	0
	210	00011100011110	0		210	11100011100001	0
	211	00011100001111	0		211	11100011110000	0
	212	00011001111100	0		212	11100110000011	0
	213	00011001111001	0		213	11100110000110	0
	214	00011001110011	0		214	11100110001100	0
	215	00011001100111	0		215	11100110011000	0
	216	00011000111110	0		216	11100111000001	0
	217	00011000011111	0		217	11100111100000	0
4(C)	218	00001110000011	-4		218	11100000001110	-2
	219	00001100000111	-4		219	11100000011001	-2
	220	00001111110000	-2		220	11100000011100	-2
	221	00001111100001	-2		221	11100000110001	-2
	222	00001111001100	-2		222	11100000111000	-2
	223	00001111000110	-2		223	11100001100001	-2
	224	00001111000011	-2		224	11100001110000	-2
	225	00001110011100	-2		225	11100011000001	-2
	226	00001110011001	-2		226	11100011100000	-2
	227	00001110001110	-2		227	11100110000001	-2
	228	00001110000111	-2		228	11100111000000	-2
	229	00001100111100	-2		229	11100000001100	-4
	230	00001100111001	-2		230	11100000011000	-4
	231	00001100110011	-2		231	11100000110000	-4
	232	00001100011110	-2		232	11100001100000	-4
	233	00001100001111	-2		233	11100011000000	-4
	234	00001111111000	0	4(D)	234	11110000000111	0
	235	00001111110001	0		235	11110000001110	0
	236	00001111100110	0		236	11110000011001	0
	237	00001111100011	0		237	11110000011100	0
	238	00001111001110	0		238	11110000110001	0
	239	00001111000111	0		239	11110000111000	0
	240	00001110011110	0		240	11110001100001	0
	241	00001110001111	0		241	11110001110000	0
	242	00001100111110	0		242	11110011000001	0
	243	00001100011111	0		243	11110011100000	0
5(C)	244	00000111111000	-2		244	11110000000110	-2
	245	00000111110001	-2		245	11110000001100	-2
	246	00000111100110	-2		246	11110000011000	-2
	247	00000111100011	-2		247	11110000110000	-2
	248	00000111000111	-2		248	11110001100000	-2
	249	00000110001111	-2		249	11110011000000	-2
	250	00000111111100	0	5(D)	250	11111000000011	0
	251	00000111111001	0		251	11111000000110	0
	252	00000111110011	0		252	11111000001100	0
	253	00000111100111	0		253	11111000011000	0
	254	00000111001111	0		254	11111000110000	0
	255	00000110011111	0		255	11111001100000	0

TABLE 12

8-bit data	Modulation codes	CDS
248	11111000110001	2
249	11111000111000	2
250	11111001100001	2
251	11111001110000	2

TABLE 13

8-bit data	Modulation codes	CDS
248	00000111001110	-2
249	00000111000111	-2
250	00000110011110	-2
251	00000110001111	-2

5. A digital modulation method for converting 8-bit digital data into 14-bit digital modulation codes, said digital modulation method comprising:

step 1 for selecting up to four 14-bit digital modulation codes for each 8-bit digital data, said 14-bit digital modulation code is selected by the procedures of

(a) selecting among the 2^{14} 14-bit digital codes, a digital code the numbers of consecutive identical bits in which are 6 or less in the first 7 bits, 2 - 7 from the second bit to 13th bit, and 5 or less in the last 6 bits, and repeating this selecting procedure,

(b) selecting among the 14-bit digital codes selected at the procedure (a), a digital code the first bit of which is "0", and the CDS of which has the absolute value equal to or less than 6, and repeating this selecting procedure,

(c) selecting among the 14-bit digital codes selected at the procedure (a), a digital code the first bit of which is "1", and the CDS of which has the absolute value equal to or less than 4, and repeating this selecting procedure,

(d) selecting among the 14-bit digital codes selected at the procedure (b), a digital code the value of CDS of which is 0, and pairing the selected 14-bit digital code with the reversal code thereof to make the 2 digital codes one group, and repeating this selecting procedure,

(e) selecting among the 14-bit digital codes selected at the procedure (b), a digital code the value of CDS of which is +2, +4 or +6, selecting among the 14-bit digital codes selected at the procedure (c), a digital code the value of CDS of which is +2 or +4, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure, and

(f) selecting 256 groups among the groups formed in the above procedures as the 14-bit digital modulation codes;

step 2 for selecting one group of 14-bit digital modulation codes among the 256 groups of the 14-bit digital modulation codes, said selected group corresponding to inputted 8-bit digital data;

step 3 for further selecting one or more 14-bit digital modulation codes in the selected group at step 2, each of the 14-bit digital modulation codes satisfying the requirement that the number of consecutive identical bits at the joint portion of the preceding 14-bit digital modulation code already selected and the 14-bit digital modulation code to be selected is 2 - 7; and

step 4 for further selecting one 14-bit digital modulation code among the selected modulation codes at step 3 so that said one 14-bit digital modulation code satisfies the requirement that the absolute value of bit DSV for each bit in the modulation code is equal to or less than 8.

6. A digital modulation method as claimed in claim 5, wherein said step 3 comprises the procedures of:
selecting any one of the digital modulation codes the first bits of which are "01", "001", "0001", "00001", "000001", and "0000001" when the preceding digital modulation code that has already been selected terminates with "10";
selecting any one of the digital modulation codes the first bits of which are "10", "110", "1110", "11110", "111110", and "1111110" when the preceding digital modulation code that has already been selected terminates with "01";
selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", "1111110", "01", "001", "0001", "00001", and "000001" when the preceding digital modulation code that has already been selected terminates with "100";
selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", "000001", "0000001", "10", "110", "1110", "11110", and "111110" when the preceding digital modulation code that has already been selected terminates with "011";
selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", "1111110", "01", "001", "0001", and "00001" when the preceding digital modulation code that has already been selected terminates with "1000";
selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", "000001", "0000001", "10", "110", "1110", and "11110" when the preceding digital modulation code that has already been selected terminates with "0111";
selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", "1111110", "01", "001", and "0001" when the preceding digital modulation code that has already been selected terminates with "10000";
selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", "000001", "0000001", "10", "110", and "1110" when the preceding digital modulation code that has already been selected terminates with "01111";

selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", "1111110", "01", and "001" when the preceding digital modulation code that has already been selected terminates with "100000"; and
selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", "000001", "0000001", "10", and "110" when the preceding digital modulation code that has already been selected terminates with "011111".

7. A digital modulation method as claimed in claim 5, wherein said step 4 comprises the procedures of:
selecting any one of the digital modulation codes the CDS of which are 0, -2, -4, and -6 when the DSV at the end of the preceding 14-bit digital modulation code that has already been selected is +4 or +2;
selecting any one of the digital modulation codes the CDS of which are +4, +2, 0, -2, and -4 when the DSV at the end of the preceding 14-bit digital modulation code that has already been selected is 0; and
selecting any one of the digital modulation codes the CDS of which are +6, +4, +2, and 0 when the DSV at the end of the preceding 14-bit digital modulation code that has already been selected is
-2 or -4;

8. A digital modulation method as claimed in claim 5, wherein said digital modulation codes are the codes described in the following Tables 17 and 18.

Table 17 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	0	01111110000001	0		0	10000001111110	0
	1	01111100110000	0		1	10000011001111	0
	2	01111100011000	0		2	10000011100111	0
	3	01111100001100	0		3	10000011110011	0
	4	01111100000110	0		4	10000011111001	0
	5	01111100000011	0		5	10000011111100	0
	6	01111001110000	0		6	10000110001111	0
	7	01111001100001	0		7	10000110011110	0
	8	01111000111000	0		8	10000111000111	0
	9	01111000110001	0		9	10000111001110	0
	10	01111000011100	0		10	10000111100011	0
	11	01111000011001	0		11	10000111100110	0
	12	01111000001110	0		12	10000111110001	0
	13	01111000000111	0		13	10000111111000	0
	14	01110011110000	0		14	10001100001111	0
	15	01110011100001	0		15	10001100011110	0
	16	01110011001100	0		16	10001100110011	0
	17	01110011000110	0		17	10001100111001	0
	18	01110011000011	0		18	10001100111100	0
	19	01110001111000	0		19	10001110000111	0
	20	01110001110001	0		20	10001110001110	0
	21	01110001100110	0		21	10001110011001	0
	22	01110001100011	0		22	10001110011100	0
	23	01110000111100	0		23	10001111000011	0
	24	01110000111001	0		24	10001111000110	0
1 (A)	25	01110000110011	0	1 (B)	25	10001111001100	0
	26	01110000011110	0		26	10001111100001	0
	27	01110000001111	0		27	10001111110000	0
	28	01100111110000	0		28	10011000001111	0
	29	01100111100001	0		29	10011000011110	0
	30	01100111001100	0		30	10011000110011	0
	31	01100111000110	0		31	10011000111001	0
	32	01100111000011	0		32	10011000111100	0
	33	01100110011100	0		33	10011001100011	0
	34	01100110011001	0		34	10011001100110	0
	35	01100110001110	0		35	10011001110001	0
	36	01100110000111	0		36	10011001111000	0
	37	01100011111000	0		37	10011100000111	0
	38	01100011110001	0		38	10011100001110	0
	39	01100011100110	0		39	10011100011001	0
	40	01100011100011	0		40	10011100011100	0
	41	01100011001110	0		41	10011100110001	0
	42	01100011000111	0		42	10011100111000	0
	43	01100001111100	0		43	10011110000011	0
	44	01100001111001	0		44	10011110000110	0
	45	01100001110011	0		45	10011110001100	0
	46	01100001100111	0		46	10011110011000	0
	47	01100000111110	0		47	10011111000001	0
	48	01100000011111	0		48	10011111100000	0
	49	01111111000001	2		49	10000011111110	2
	50	01111110011000	2		50	10000110011111	2
	51	01111110001100	2		51	10000111001111	2
	52	01111110000110	2		52	10000111100111	2
	53	01111110000011	2		53	10000111110011	2
	54	01111100111000	2		54	10000111111001	2
	55	01111100110001	2		55	10000111111100	2
	56	01111100011100	2		56	10001100011111	2
	57	01111100011001	2		57	10001100111110	2
	58	01111100001110	2		58	10001110001111	2
	59	01111100000111	2		59	10001110011110	2
	60	01111001111000	2		60	10001111000111	2
	61	01111001110001	2		61	10001111001110	2
	62	01111001100110	2		62	10001111100011	2
	63	01111001100011	2		63	10001111100110	2
	64	01111000111100	2		64	10001111110001	2
	65	01111000111001	2		65	10001111111000	2
	66	01111000110011	2		66	10011000011111	2

Table 17 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
1 (A)	67	01111000011110	2	1 (B)	67	10011000111110	2
	68	01111000001111	2		68	10011001100111	2
	69	01110011111000	2		69	10011001110011	2
	70	01110011110001	2		70	10011001111001	2
	71	01110011100110	2		71	10011001111100	2
	72	01110011100011	2		72	10011100001111	2
	73	01110011001110	2		73	10011100011110	2
	74	01110011000111	2		74	10011100110011	2
	75	01110001111100	2		75	10011100111001	2
	76	01110001111001	2		76	10011100111100	2
	77	01110001110011	2		77	10011110000111	2
	78	01110001100111	2		78	10011110001110	2
	79	01110000111110	2		79	10011110011001	2
	80	01110000011111	2		80	10011110011100	2
	81	01100111111000	2		81	10011111000011	2
	82	01100111110001	2		82	10011111000110	2
	83	01100111100110	2		83	10011111001100	2
	84	01100111100011	2		84	10011111100001	2
	85	01100111001110	2		85	10011111110000	2
	86	01100111000111	2		86	10011111000111	4
	87	01100110011110	2	2 (B)	87	11000011111110	4
	88	01100110001111	2		88	11000110011111	4
	89	01100011111100	2		89	11000111001111	4
	90	01100011111001	2		90	11000111100111	4
	91	01100011110011	2		91	11000111110011	4
	92	01100011100111	2		92	11000111111001	4
	93	01100011001111	2		93	11000111111100	4
	94	01100001111110	2		94	11001100011111	4
	95	01111111001100	4		95	11001100111110	4
	96	01111111000110	4		96	11001110001111	4
	97	01111111000011	4		97	11001110011110	4
	98	01111110011100	4		98	11001111000111	4
	99	01111110011001	4		99	11001111001110	4
	100	01111110001110	4		100	11001111100011	4
	101	01111110000111	4		101	11000001111110	2
	102	01111100111100	4		102	11000011001111	2
	103	01111100111001	4		103	11000011100111	2
	104	01111100110011	4		104	11000011110011	2
	105	01111100011110	4		105	11000011111001	2
	106	01111100001111	4		106	11000011111100	2
	107	01111001111100	4		107	11000110001111	2
	108	01111001111001	4		108	11000110011110	2
	109	01111001110011	4		109	11000111000111	2
	110	01111001100111	4		110	11000111001110	2
	111	01111000111110	4		111	11000111100011	2
	112	01111000011111	4		112	11000111100110	2
	113	01110011111100	4		113	11000111110001	2
	114	01110011111001	4		114	11000111111000	2
	115	01110011110011	4		115	11001100001111	2
	116	01110011100111	4		116	11001100011110	2
	117	01110011001111	4		117	11001100110011	2
	118	01110001111110	4		118	11001100111001	2
	119	01100111111100	4		119	11001100111100	2
	120	01100111111001	4		120	11001110000111	2
	121	01100111110011	4		121	11001110001110	2
	122	01100111100111	4		122	11001110011001	2
	123	01100111001111	4		123	11001110011100	2
	124	01100110011111	4		124	11001111000011	2
	125	01100011111110	4		125	11001111000110	2
	126	01111111000111	6		126	11001111001100	2
	127	01111110001111	6		127	11001111100001	2
	128	01111100011111	6		128	11001111110000	2
2 (A)	129	00111111100000	0		129	11000000011111	0
	130	00111111000001	0		130	11000000111110	0
	131	00111110011000	0		131	11000001100111	0
	132	00111110001100	0		132	11000001110011	0
	133	00111110000110	0		133	11000001111001	0

Table 17 (CDS ≥ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
2 (A)	134	00111110000011	0	2 (B)	134	11000001111100	0
	135	00111100111000	0		135	11000011000111	0
	136	00111100110001	0		136	11000011001110	0
	137	00111100011100	0		137	11000011100011	0
	138	00111100011001	0		138	11000011100110	0
	139	00111100001110	0		139	11000011110001	0
	140	00111100000111	0		140	11000011111000	0
	141	00111001111000	0		141	11000110000111	0
	142	00111001110001	0		142	11000110001110	0
	143	00111001100110	0		143	11000110011001	0
	144	00111001100011	0		144	11000110011100	0
	145	00111000111100	0		145	11000111000011	0
	146	00111000111001	0		146	11000111000110	0
	147	00111000110011	0		147	11000111001100	0
	148	00111000011110	0		148	11000111100001	0
	149	00111000001111	0		149	11000111110000	0
	150	00110011111000	0		150	11001100000111	0
	151	00110011110001	0		151	11001100001110	0
	152	00110011100110	0		152	11001100011001	0
	153	00110011100011	0		153	11001100011100	0
	154	00110011001110	0		154	11001100110001	0
	155	00110011000111	0		155	11001100111000	0
	156	00110001111100	0		156	11001110000011	0
	157	00110001111001	0		157	11001110000110	0
	158	00110001110011	0		158	11001110001100	0
	159	00110001100111	0		159	11001110011000	0
	160	00110000111110	0		160	11001111000001	0
	161	00110000011111	0		161	11001111100000	0
	162	00111111100001	2		162	11001111100110	4
	163	00111111001100	2		163	11001111110001	4
	164	00111111000110	2		164	11001111111000	4
	165	00111111000011	2	3 (B)	165	11100001111110	4
	166	00111110011100	2		166	11100011001111	4
	167	00111110011001	2		167	11100011100111	4
	168	00111110001110	2		168	11100011110011	4
	169	00111110000111	2		169	11100011111001	4
	170	00111100111100	2		170	11100011111100	4
	171	00111100111001	2		171	11100110001111	4
	172	00111100110011	2		172	11100110011110	4
	173	00111100011110	2		173	11100111000111	4
	174	00111100001111	2		174	11100111001110	4
	175	00111001111100	2		175	11100111100011	4
	176	00111001111001	2		176	11100111100110	4
	177	00111001110011	2		177	11100111110001	4
	178	00111001100111	2		178	11100111111000	4
	179	00111000111110	2		179	11100000011111	2
	180	00111000011111	2		180	11100000111110	2
	181	00110011111100	2		181	11100001100111	2
	182	00110011111001	2		182	11100001110011	2
	183	00110011110011	2		183	11100001111001	2
	184	00110011100111	2		184	11100001111100	2
	185	00110011001111	2		185	11100011000111	2
	186	00110001111110	2		186	11100011001110	2
	187	00111111100110	4		187	11100011100011	2
	188	00111111100011	4		188	11100011100110	2
	189	00111111001110	4		189	11100011110001	2
	190	00111111000111	4		190	11100011111000	2
	191	00111110011110	4		191	11100110000111	2
	192	00111110001111	4		192	11100110001110	2
	193	00111100111110	4		193	11100110011001	2
	194	00111100011111	4		194	11100110011100	2
	195	00111001111110	4		195	11100111000011	2
	196	00110011111110	4		196	11100111000110	2
	197	00111111100111	6		197	11100111001100	2
	198	00111111001111	6		198	11100111100001	2
	199	00111110011111	6		199	11100111110000	2

Table 17 (CDS $\geq$ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
3 (A)	200	00011111110000	0	3 (B)	200	11100000001111	0
	201	00011111100001	0		201	11100000011110	0
	202	00011111001100	0		202	11100000110011	0
	203	00011111000110	0		203	11100000111001	0
	204	00011111000011	0		204	11100000111100	0
	205	00011110011100	0		205	11100001100011	0
	206	00011110011001	0		206	11100001100110	0
	207	00011110001110	0		207	11100001110001	0
	208	00011110000111	0		208	11100001111000	0
	209	00011100111100	0		209	11100011000011	0
	210	00011100111001	0		210	11100011000110	0
	211	00011100110011	0		211	11100011001100	0
	212	00011100011110	0		212	11100011100001	0
	213	00011100001111	0		213	11100011110000	0
	214	00011001111100	0		214	11100110000011	0
	215	00011001111001	0		215	11100110000110	0
	216	00011001110011	0		216	11100110001100	0
	217	00011001100111	0		217	11100110011000	0
	218	00011000111110	0		218	11100111000001	0
	219	00011000011111	0		219	11100111100000	0
	220	00011111110001	2	4 (B)	220	11110000001111	2
	221	00011111100110	2		221	11110000011110	2
	222	00011111100011	2		222	11110000110011	2
	223	00011111001110	2		223	11110000111001	2
	224	00011111000111	2		224	11110000111100	2
	225	00011110011110	2		225	11110001100011	2
	226	00011110001111	2		226	11110001100110	2
	227	00011100111110	2		227	11110001110001	2
	228	00011100011111	2		228	11110001111000	2
	229	00011001111110	2		229	11110011000011	2
	230	00011111110011	4		230	11110011000110	2
	231	00011111100111	4		231	11110011001100	2
	232	00011111001111	4		232	11110011100001	2
	233	00011110011111	4		233	11110011110000	2
4 (A)	234	00001111111000	0		234	11110000000111	0
	235	00001111110001	0		235	11110000001110	0
	236	00001111100110	0		236	11110000011001	0
	237	00001111100011	0		237	11110000011100	0
	238	00001111001110	0		238	11110000110001	0
	239	00001111000111	0		239	11110000111000	0
	240	00001110011110	0		240	11110001100001	0
	241	00001110001111	0		241	11110001110000	0
	242	00001100111110	0		242	11110011000001	0
	243	00001100011111	0		243	11110011100000	0
	244	00001111111001	2	5 (B)	244	11111000000111	2
	245	00001111110011	2		245	11111000011100	2
	246	00001111100111	2		246	11111000110001	2
	247	00001111001111	2		247	11111000111000	2
	248	00001110011111	2		248	11111001110000	2
5 (A)	249	00000111111100	0		249	11111000000011	0
	250	00000111111001	0		250	11111000000110	0
	251	00000111110011	0		251	11111000001100	0
	252	00000111100111	0		252	11111000011000	0
	253	00000111001111	0		253	11111000110000	0
	254	00000110011111	0		254	11111001100000	0
6 (A)	255	00000011111110	0	6 (B)	255	11111100000001	0

Table 18 (CDS ≤ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	0	01111110000001	0		0	10000001111110	0
	1	01111100110000	0		1	10000011001111	0
	2	01111100011000	0		2	10000011100111	0
	3	01111100001100	0		3	10000011110011	0
	4	01111100000110	0		4	10000011111001	0
	5	01111100000011	0		5	10000011111100	0
	6	01111001110000	0		6	10000110001111	0
	7	01111001100001	0		7	10000110011110	0
	8	01111000111000	0		8	10000111000111	0
	9	01111000110001	0		9	10000111001110	0
	10	01111000011100	0		10	10000111100011	0
	11	01111000011001	0		11	10000111100110	0
	12	01111000001110	0		12	10000111110001	0
	13	01111000000111	0		13	10000111111000	0
	14	01110011110000	0		14	10001100001111	0
	15	01110011100001	0		15	10001100011110	0
	16	01110011001100	0		16	10001100110011	0
	17	01110011000110	0		17	10001100111001	0
	18	01110011000011	0		18	10001100111100	0
	19	01110001111000	0		19	10001110000111	0
	20	01110001110001	0		20	10001110001110	0
	21	01110001100110	0		21	10001110011001	0
	22	01110001100011	0		22	10001110011100	0
	23	01110000111100	0		23	10001111000011	0
	24	01110000111001	0		24	10001111000110	0
	25	01110000110011	0		25	10001111001100	0
	26	01110000011110	0		26	10001111100001	0
1 (C)	27	01110000001111	0	1 (D)	27	10001111110000	0
	28	01100111110000	0		28	10011000001111	0
	29	01100111100001	0		29	10011000011110	0
	30	01100111001100	0		30	10011000110011	0
	31	01100111000110	0		31	10011000111001	0
	32	01100111000011	0		32	10011000111100	0
	33	01100110011100	0		33	10011001100011	0
	34	01100110011001	0		34	10011001100110	0
	35	01100110001110	0		35	10011001110001	0
	36	01100110000111	0		36	10011001111000	0
	37	01100011111000	0		37	10011100000111	0
	38	01100011110001	0		38	10011100001110	0
	39	01100011100110	0		39	10011100011001	0
	40	01100011100011	0		40	10011100011100	0
	41	01100011001110	0		41	10011100110001	0
	42	01100011000111	0		42	10011100111000	0
	43	01100001111100	0		43	10011110000011	0
	44	01100001111001	0		44	10011110000110	0
	45	01100001110011	0		45	10011110001100	0
	46	01100001100111	0		46	10011110011000	0
	47	01100000111110	0		47	10011111000001	0
	48	01100000011111	0		48	10011111100000	0
	49	01111100000001	-2		49	10000000111110	-2
	50	01111001100000	-2		50	10000001100111	-2
	51	01111000110000	-2		51	10000001110011	-2
	52	01111000011000	-2		52	10000001111001	-2
	53	01111000001100	-2		53	10000001111100	-2
	54	01111000000110	-2		54	10000011000111	-2
	55	01111000000011	-2		55	10000011001110	-2
	56	01110011100000	-2		56	10000011100011	-2
	57	01110011000001	-2		57	10000011100110	-2
	58	01110001110000	-2		58	10000011110001	-2
	59	01110001100001	-2		59	10000011111000	-2
	60	01110000111000	-2		60	10000110000111	-2
	61	01110000110001	-2		61	10000110001110	-2
	62	01110000011100	-2		62	10000110011001	-2
	63	01110000011001	-2		63	10000110011100	-2
	64	01110000001110	-2		64	10000111000011	-2
	65	01110000000111	-2		65	10000111000110	-2
	66	01100111100000	-2		66	10000111001100	-2

Table 18 (CDS ≤ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	67	01100111000001	-2		67	10000111100001	-2
	68	01100110011000	-2		68	10000111110000	-2
	69	01100110001100	-2		69	10001100000111	-2
	70	01100110000110	-2		70	10001100001110	-2
	71	01100110000011	-2		71	10001100011001	-2
	72	01100011110000	-2		72	10001100011100	-2
	73	01100011100001	-2		73	10001100110001	-2
	74	01100011001100	-2		74	10001100111000	-2
	75	01100011000110	-2		75	10001110000011	-2
	76	01100011000011	-2		76	10001110000110	-2
1 (C)	77	01100001111000	-2		77	10001110001100	-2
	78	01100001110001	-2		78	10001110011000	-2
	79	01100001100110	-2		79	10001111000001	-2
	80	01100001100011	-2		80	10001111100000	-2
	81	01100000111100	-2		81	10011000000111	-2
	82	01100000111001	-2		82	10011000001110	-2
	83	01100000110011	-2		83	10011000011001	-2
	84	01100000011110	-2		84	10011000011100	-2
	85	01100000001111	-2		85	10011000110001	-2
	86	01100000111000	-4		86	10011000111000	-2
	87	00111100000001	-4	1 (D)	87	10011001100001	-2
	88	00111001100000	-4		88	10011001110000	-2
	89	00111000110000	-4		89	10011100000011	-2
	90	00111000011000	-4		90	10011100000110	-2
	91	00111000001100	-4		91	10011100001100	-2
	92	00111000000110	-4		92	10011100011000	-2
	93	00111000000011	-4		93	10011100110000	-2
	94	00110011100000	-4		94	10011110000001	-2
	95	00110011000001	-4		95	10000000110011	-4
	96	00110001110000	-4		96	10000000111001	-4
	97	00110001100001	-4		97	10000000111100	-4
	98	00110000111000	-4		98	10000001100011	-4
2 (C)	99	00110000110001	-4		99	10000001100110	-4
	100	00110000011100	-4		100	10000001110001	-4
	101	00111110000001	-2		101	10000001111000	-4
	102	00111100110000	-2		102	10000011000011	-4
	103	00111100011000	-2		103	10000011000110	-4
	104	00111100001100	-2		104	10000011001100	-4
	105	00111100000110	-2		105	10000011100001	-4
	106	00111100000011	-2		106	10000011110000	-4
	107	00111001110000	-2		107	10000110000011	-4
	108	00111001100001	-2		108	10000110000110	-4
	109	00111000111000	-2		109	10000110001100	-4
	110	00111000110001	-2		110	10000110011000	-4
	111	00111000011100	-2		111	10000111000001	-4
	112	00111000011001	-2		112	10000111100000	-4
	113	00111000001110	-2		113	10001100000011	-4
	114	00111000000111	-2		114	10001100000110	-4
	115	00110011110000	-2		115	10001100001100	-4
	116	00110011100001	-2		116	10001100011000	-4
	117	00110011001100	-2		117	10001100110000	-4
	118	00110011000110	-2		118	10001110000001	-4
	119	00110011000011	-2		119	10011000000011	-4
	120	00110001111000	-2		120	10011000000110	-4
	121	00110001110001	-2		121	10011000001100	-4
	122	00110001100110	-2		122	10011000011000	-4
	123	00110001100011	-2		123	10011000110000	-4
	124	00110000111100	-2		124	10011001100000	-4
	125	00110000111001	-2		125	10011100000001	-4
	126	00110000110011	-2		126	10000000111000	-6
	127	00110000011110	-2		127	10000001110000	-6
	128	00110000001111	-2		128	10000011100000	-6
	129	00111111100000	0		129	11000000011111	0
	130	00111111000001	0		130	11000000111110	0
	131	00111110011000	0	2 (D)	131	11000001100111	0
	132	00111110001100	0		132	11000001110011	0

Table 18 (CDS ≤ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
2 (C)	133	00111110000110	0	2 (D)	133	11000001111001	0
	134	00111110000011	0		134	11000001111100	0
	135	00111100111000	0		135	11000011000111	0
	136	00111100110001	0		136	11000011001110	0
	137	00111100011100	0		137	11000011100011	0
	138	00111100011001	0		138	11000011100110	0
	139	00111100001110	0		139	11000011110001	0
	140	00111100000111	0		140	11000011111000	0
	141	00111001111000	0		141	11000110000111	0
	142	00111001110001	0		142	11000110001110	0
	143	00111001100110	0		143	11000110011001	0
	144	00111001100011	0		144	11000110011100	0
	145	00111000111100	0		145	11000111000011	0
	146	00111000111001	0		146	11000111000110	0
	147	00111000110011	0		147	11000111001100	0
	148	00111000011110	0		148	11000111100001	0
	149	00111000001111	0		149	11000111110000	0
	150	00110011111000	0		150	11001100000111	0
	151	00110011110001	0		151	11001100001110	0
	152	00110011100110	0		152	11001100011001	0
	153	00110011100011	0		153	11001100011100	0
	154	00110011001110	0		154	11001100110001	0
	155	00110011000111	0		155	11001100111000	0
	156	00110001111100	0		156	11001110000011	0
	157	00110001111001	0		157	11001110000110	0
	158	00110001110011	0		158	11001110001100	0
	159	00110001100111	0		159	11001110011000	0
	160	00110000111110	0		160	11001111000001	0
	161	00110000011111	0		161	11001111100000	0
	162	00110000011001	-4		162	11000000011110	-2
	163	00110000001110	-4		163	11000000110011	-2
	164	00110000000111	-4		164	11000000111001	-2
3 (C)	165	00011110000001	-4		165	11000000111100	-2
	166	00011100110000	-4		166	11000001100011	-2
	167	00011100011000	-4		167	11000001100110	-2
	168	00011100001100	-4		168	11000001110001	-2
	169	00011100000110	-4		169	11000001111000	-2
	170	00011100000011	-4		170	11000011000011	-2
	171	00011001110000	-4		171	11000011000110	-2
	172	00011001100001	-4		172	11000011001100	-2
	173	00011000111000	-4		173	11000011100001	-2
	174	00011000110001	-4		174	11000011110000	-2
	175	00011000011100	-4		175	11000110000011	-2
	176	00011000011001	-4		176	11000110000110	-2
	177	00011000001110	-4		177	11000110001100	-2
	178	00011000000111	-4		178	11000110011000	-2
	179	00011111100000	-2		179	11000111000001	-2
	180	00011111000001	-2		180	11000111100000	-2
	181	00011110011000	-2		181	11001100000011	-2
	182	00011110001100	-2		182	11001100000110	-2
	183	00011110000110	-2		183	11001100001100	-2
	184	00011110000011	-2		184	11001100011000	-2
	185	00011100111000	-2		185	11001100110000	-2
	186	00011100110001	-2		186	11001110000001	-2
	187	00011100011100	-2		187	11000000011001	-4
	188	00011100011001	-2		188	11000000011100	-4
	189	00011100001110	-2		189	11000000110001	-4
	190	00011100000111	-2		190	11000000111000	-4
	191	00011001111000	-2		191	11000001100001	-4
	192	00011001110001	-2		192	11000001110000	-4
	193	00011001100110	-2		193	11000011000001	-4
	194	00011001100011	-2		194	11000011100000	-4
	195	00011000111100	-2		195	11000110000001	-4
	196	00011000111001	-2		196	11001100000001	-4
	197	00011000110011	-2		197	11000000011000	-6
	198	00011000011110	-2		198	11000000110000	-6
	199	00011000001111	-2		199	11000001100000	-6

Table 18 (CDS ≤ 0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
3 (C)	200	00011111110000	0	3 (D)	200	11100000001111	0
	201	00011111100001	0		201	11100000011110	0
	202	00011111001100	0		202	11100000110011	0
	203	00011111000110	0		203	11100000111001	0
	204	00011111000011	0		204	11100000111100	0
	205	00011110011100	0		205	11100001100011	0
	206	00011110011001	0		206	11100001100110	0
	207	00011110001110	0		207	11100001110001	0
	208	00011110000111	0		208	11100001111000	0
	209	00011100111100	0		209	11100011000011	0
	210	00011100111001	0		210	11100011000110	0
	211	00011100110011	0		211	11100011001100	0
	212	00011100011110	0		212	11100011100001	0
	213	00011100001111	0		213	11100011110000	0
	214	00011001111100	0		214	11100110000011	0
	215	00011001111001	0		215	11100110000110	0
	216	00011001110011	0		216	11100110001100	0
	217	00011001100111	0		217	11100110011000	0
	218	00011000111110	0		218	11100111000001	0
	219	00011000011111	0		219	11100111100000	0
4 (C)	220	00001111110000	-2		220	11100000001110	-2
	221	00001111100001	-2		221	11100000011001	-2
	222	00001111001100	-2		222	11100000011100	-2
	223	00001111000110	-2		223	11100000110001	-2
	224	00001111000011	-2		224	11100000111000	-2
	225	00001110011100	-2		225	11100001100001	-2
	226	00001110011001	-2		226	11100001110000	-2
	227	00001110001110	-2		227	11100011000001	-2
	228	00001110000111	-2		228	11100011100000	-2
	229	00001100111100	-2		229	11100110000001	-2
	230	00001100111001	-2		230	11100000001100	-4
	231	00001100110011	-2		231	11100000011000	-4
	232	00001100011110	-2		232	11100000110000	-4
	233	00001100001111	-2		233	11100001100000	-4
	234	00001111111000	0	4 (D)	234	11110000000111	0
	235	00001111110001	0		235	11110000001110	0
	236	00001111100110	0		236	11110000011001	0
	237	00001111100011	0		237	11110000011100	0
	238	00001111001110	0		238	11110000110001	0
	239	00001111000111	0		239	11110000111000	0
	240	00001110011110	0		240	11110001100001	0
	241	00001110001111	0		241	11110001110000	0
	242	00001100111110	0		242	11110011000001	0
	243	00001100011111	0		243	11110011100000	0
5 (C)	244	00000111111000	-2		244	11110000000110	-2
	245	00000111100011	-2		245	11110000001100	-2
	246	00000111001110	-2		246	11110000011000	-2
	247	00000111000111	-2		247	11110000110000	-2
	248	00000110001111	-2		248	11110001100000	-2
	249	00000111111100	0	5 (D)	249	11111000000011	0
	250	00000111111001	0		250	11111000000110	0
	251	00000111110011	0		251	11111000001100	0
	252	00000111100111	0		252	11111000011000	0
	253	00000111001111	0		253	11111000110000	0
	254	00000110011111	0		254	11111001100000	0
6 (C)	255	00000011111110	0	6 (D)	255	11111100000001	0

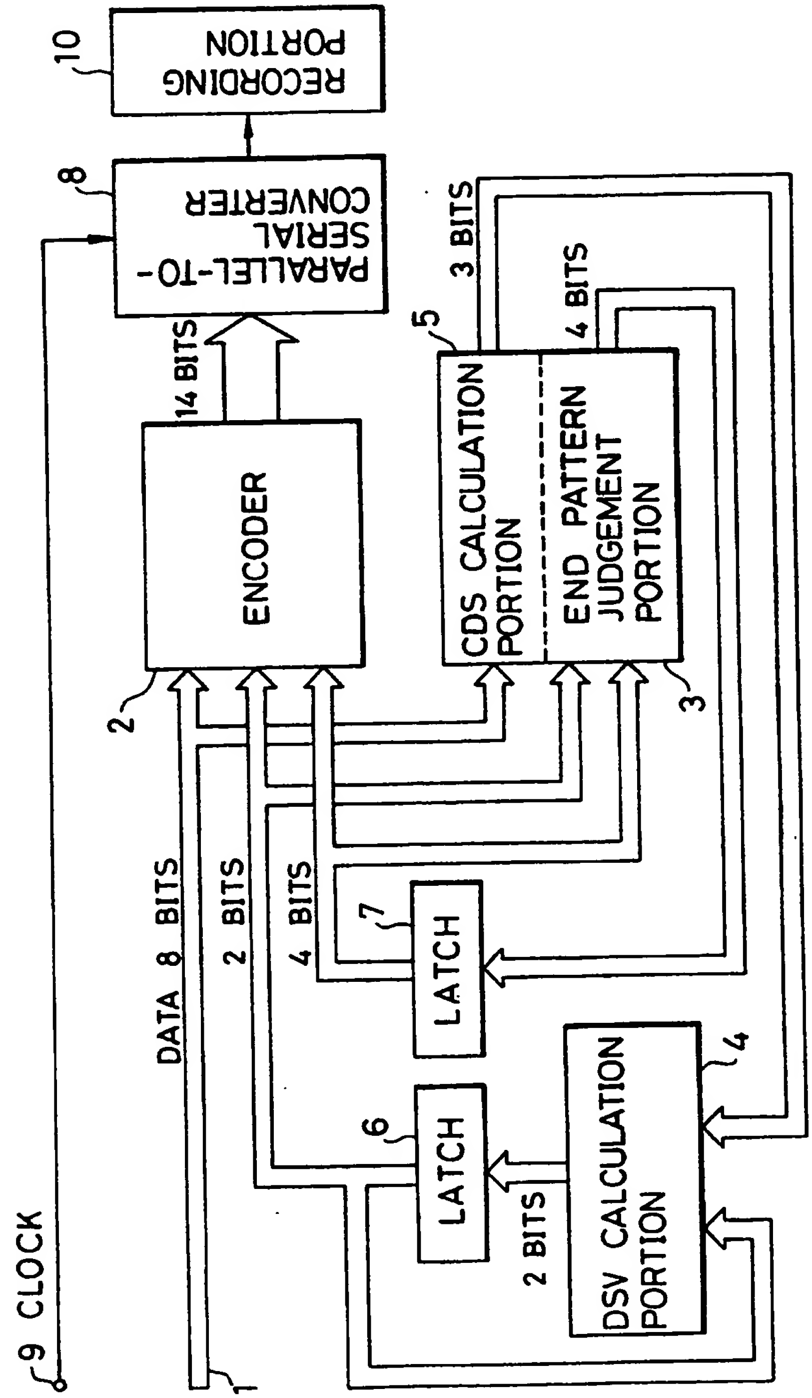

RECORDING PORTION
10
PARALLEL-TO-SERIAL CONVERTER
8
14 BITS
ENCODER
2
3 BITS
4 BITS
5
CDS CALCULATION PORTION
END PATTERN JUDGEMENT PORTION
3
DATA 8 BITS
2 BITS
4 BITS
LATCH
7
LATCH
6
2 BITS
DSV CALCULATION PORTION
4
9 CLOCK
1

FIG.1

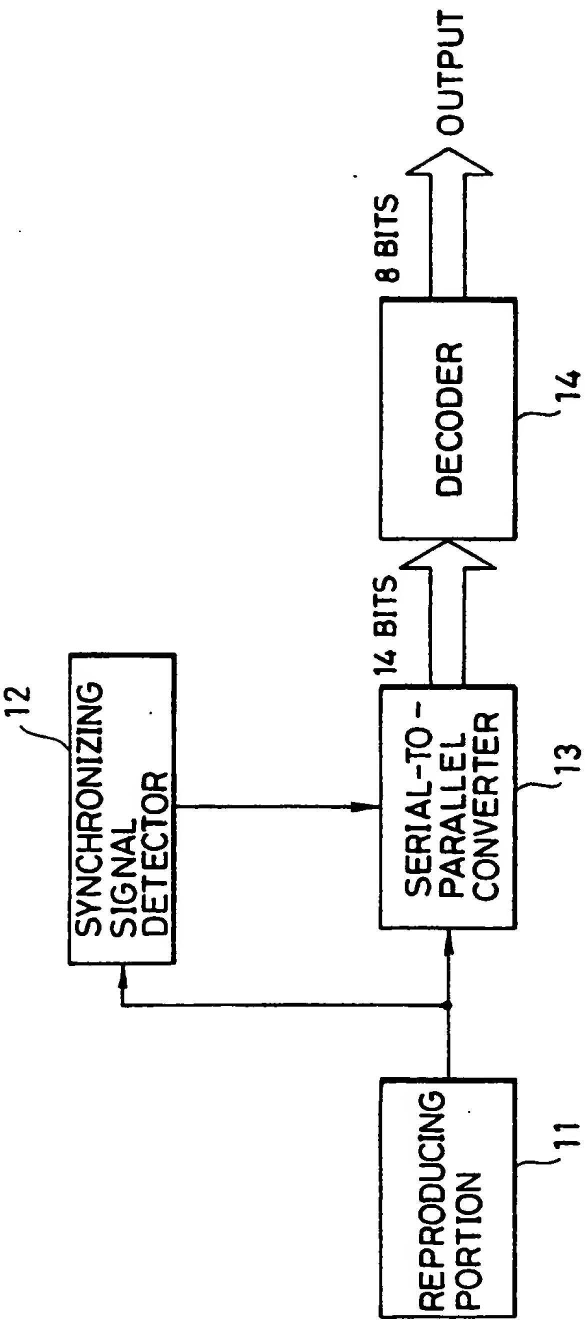

OUTPUT
8 BITS
DECODER
14
14 BITS
12
SYNCHRONIZING SIGNAL DETECTOR
SERIAL-TO-PARALLEL CONVERTER
13
REPRODUCING PORTION
11

FIG. 2

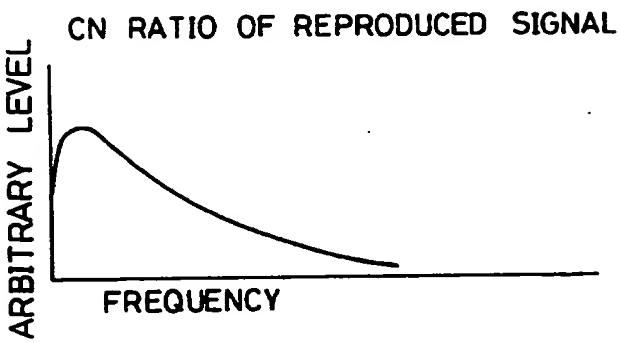


FIG.3A

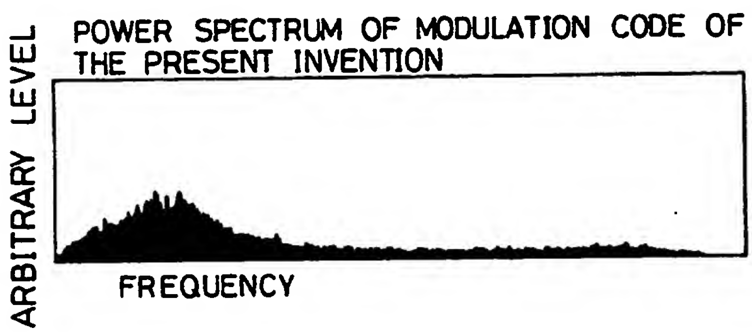


FIG.3B

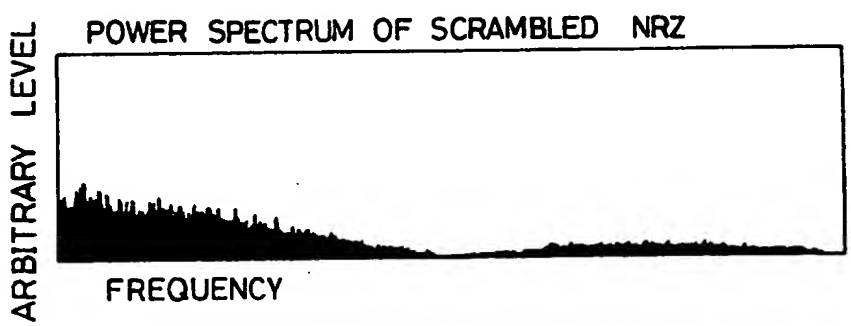


FIG.3C

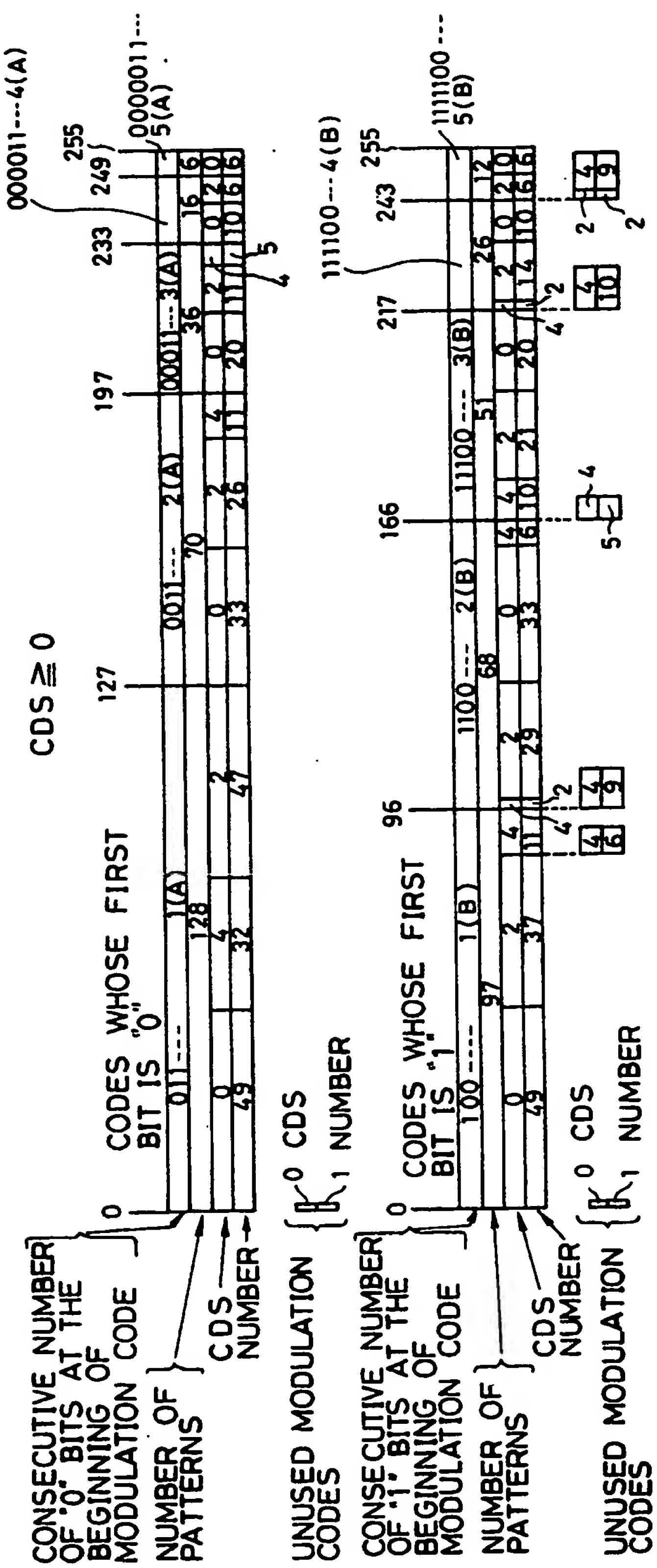

CDS ≧ 0
CODES WHOSE FIRST BIT IS "0"
CODES WHOSE FIRST BIT IS "1"
CONSECUTIVE NUMBER OF "0" BITS AT THE BEGINNING OF MODULATION CODE
CONSECUTIVE NUMBER OF "1" BITS AT THE BEGINNING OF MODULATION CODE
NUMBER OF PATTERNS
CDS
NUMBER
UNUSED MODULATION CODES
000011---4(A)
0000011---5(A)
111100---4(B)
1111100---5(B)

FIG.4

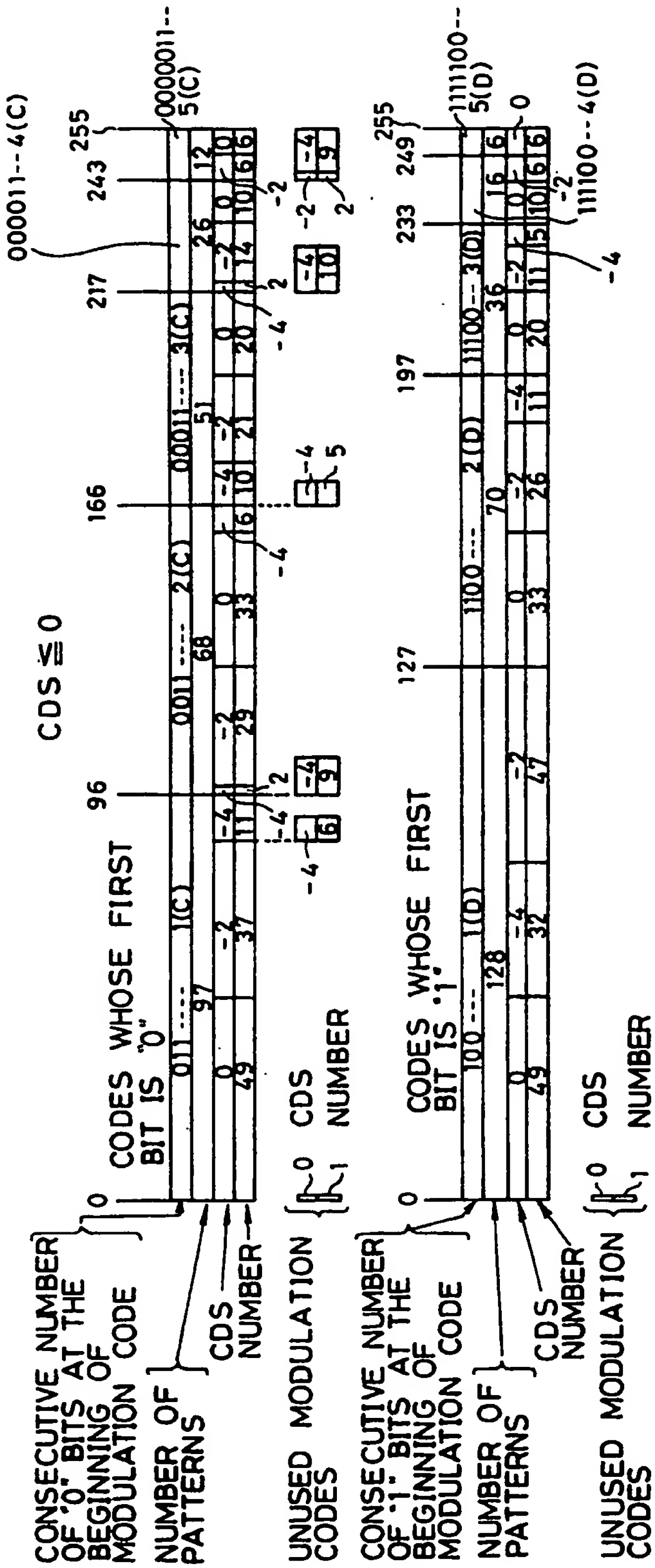
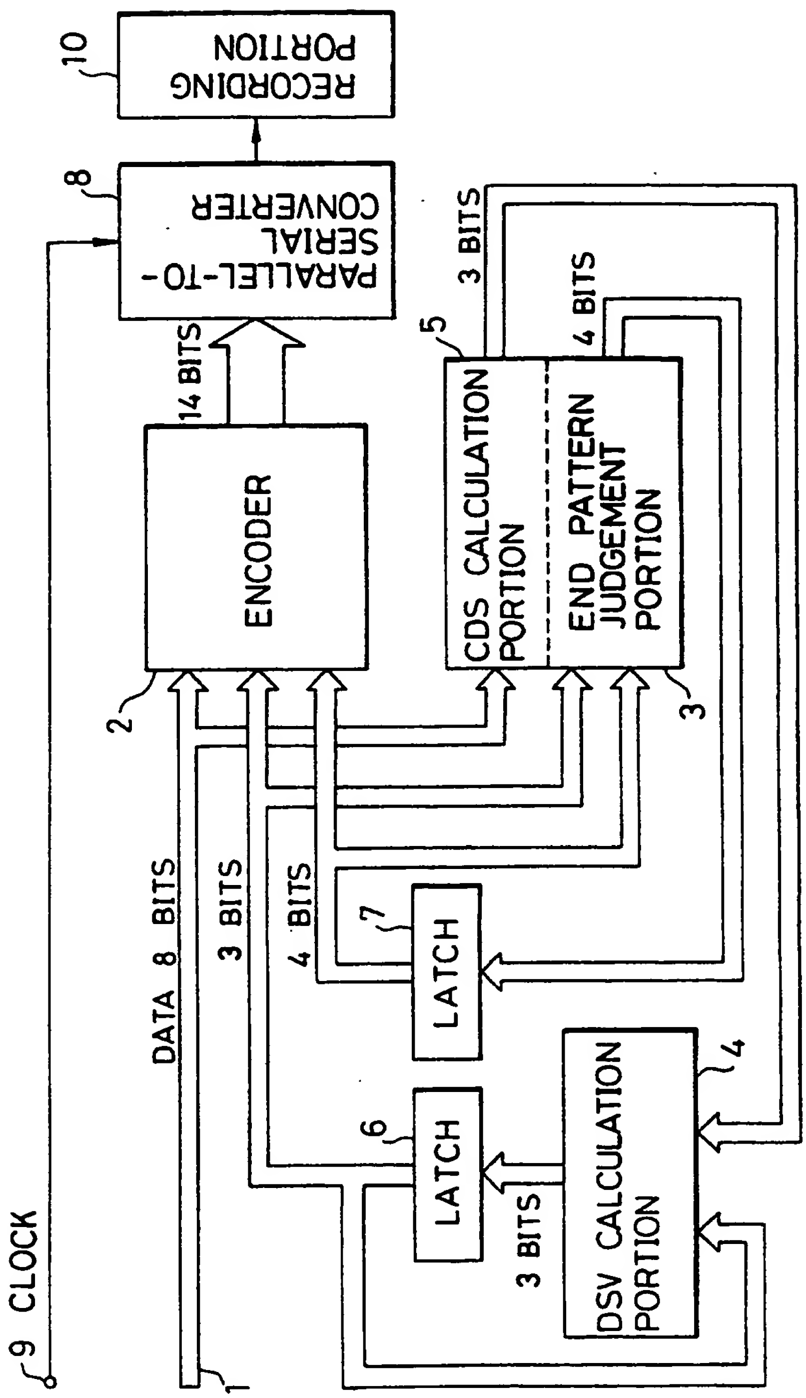

CDS ≦ 0
CODES WHOSE FIRST BIT IS "0"
CODES WHOSE FIRST BIT IS "1"
CONSECUTIVE NUMBER OF "0" BITS AT THE BEGINNING OF MODULATION CODE
CONSECUTIVE NUMBER OF "1" BITS AT THE BEGINNING OF MODULATION CODE
NUMBER OF PATTERNS
CDS
NUMBER
UNUSED MODULATION CODES
0
96
166
217
243
255
127
197
233
249
011----1(C)
0011----2(C)
00011----3(C)
000011--4(C)
0000011--5(C)
100---1(D)
1100---2(D)
11100---3(D)
111100--4(D)
1111100--5(D)
97
68
51
26
12
128
70
36
16
6

FIG.5



RECORDING PORTION
10
PARALLEL-TO-SERIAL CONVERTER
8
14 BITS
ENCODER
2
CDS CALCULATION PORTION
END PATTERN JUDGEMENT PORTION
5
3
3 BITS
4 BITS
DATA 8 BITS
3 BITS
4 BITS
LATCH
7
LATCH
6
DSV CALCULATION PORTION
4
3 BITS
9 CLOCK
1

FIG.6

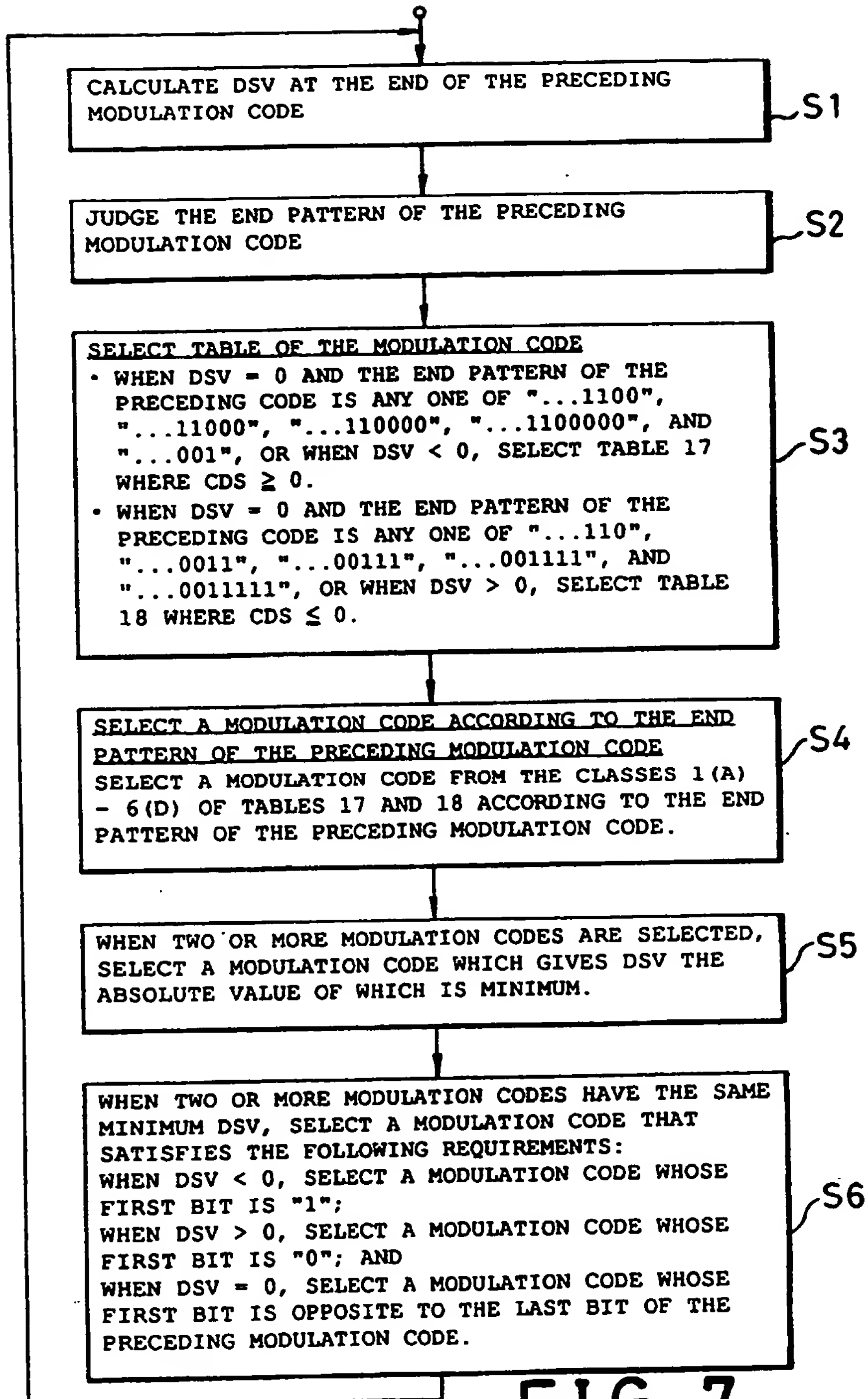

CALCULATE DSV AT THE END OF THE PRECEDING MODULATION CODE
S1
JUDGE THE END PATTERN OF THE PRECEDING MODULATION CODE
S2
SELECT TABLE OF THE MODULATION CODE
• WHEN DSV = 0 AND THE END PATTERN OF THE PRECEDING CODE IS ANY ONE OF "...1100", "...11000", "...110000", "...1100000", AND "...001", OR WHEN DSV < 0, SELECT TABLE 17 WHERE CDS ≧ 0.
• WHEN DSV = 0 AND THE END PATTERN OF THE PRECEDING CODE IS ANY ONE OF "...110", "...0011", "...00111", "...001111", AND "...0011111", OR WHEN DSV > 0, SELECT TABLE 18 WHERE CDS ≦ 0.
S3
SELECT A MODULATION CODE ACCORDING TO THE END PATTERN OF THE PRECEDING MODULATION CODE
SELECT A MODULATION CODE FROM THE CLASSES 1(A) - 6(D) OF TABLES 17 AND 18 ACCORDING TO THE END PATTERN OF THE PRECEDING MODULATION CODE.
S4
WHEN TWO OR MORE MODULATION CODES ARE SELECTED, SELECT A MODULATION CODE WHICH GIVES DSV THE ABSOLUTE VALUE OF WHICH IS MINIMUM.
S5
WHEN TWO OR MORE MODULATION CODES HAVE THE SAME MINIMUM DSV, SELECT A MODULATION CODE THAT SATISFIES THE FOLLOWING REQUIREMENTS:
WHEN DSV < 0, SELECT A MODULATION CODE WHOSE FIRST BIT IS "1";
WHEN DSV > 0, SELECT A MODULATION CODE WHOSE FIRST BIT IS "0"; AND
WHEN DSV = 0, SELECT A MODULATION CODE WHOSE FIRST BIT IS OPPOSITE TO THE LAST BIT OF THE PRECEDING MODULATION CODE.
S6

FIG.7

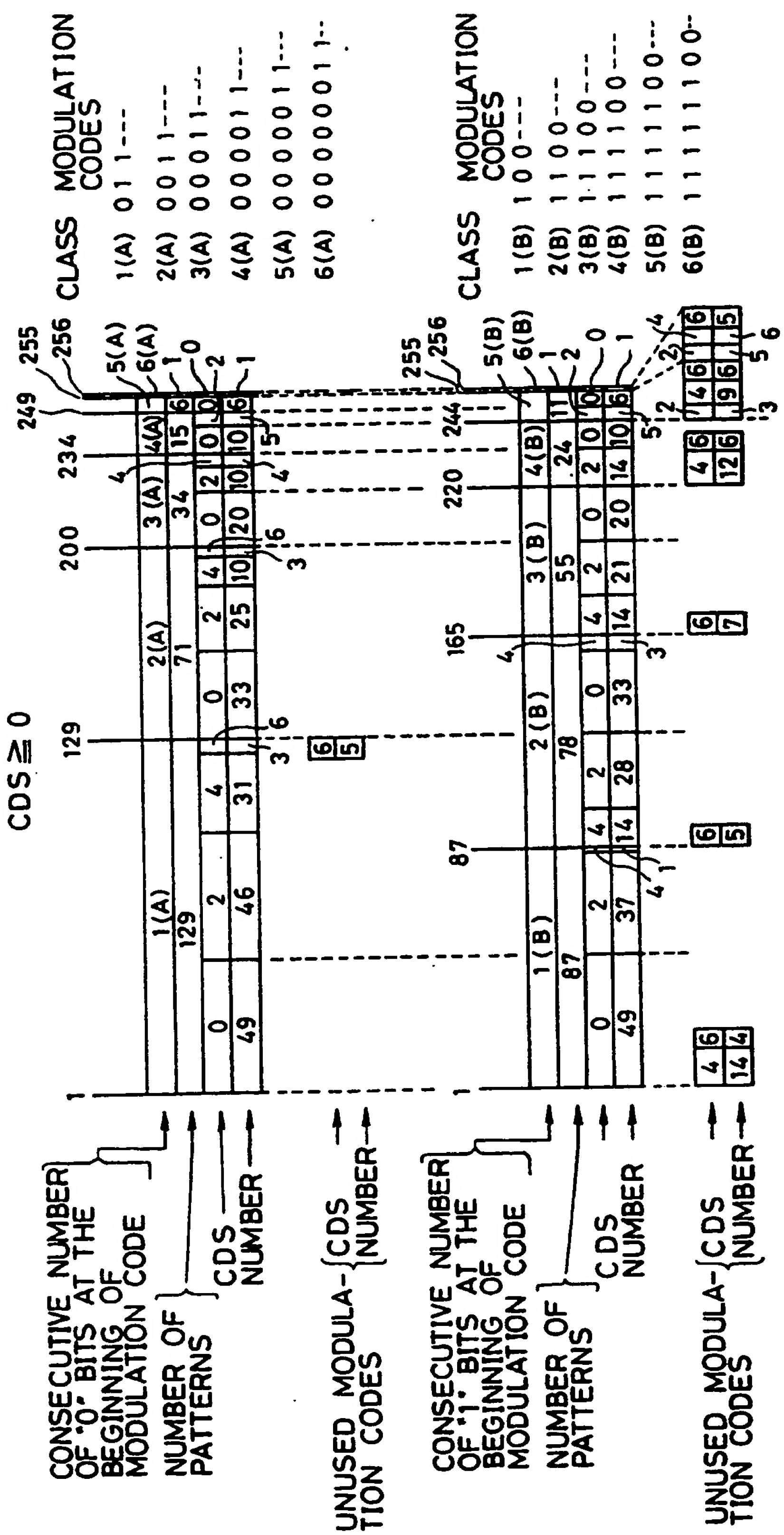

CDS ≧ 0
CONSECUTIVE NUMBER OF "0" BITS AT THE BEGINNING OF MODULATION CODE
NUMBER OF PATTERNS
CDS
NUMBER
UNUSED MODULATION CODES
CONSECUTIVE NUMBER OF "1" BITS AT THE BEGINNING OF MODULATION CODE
CLASS MODULATION CODES
1(A) 0 1 1 - - -
2(A) 0 0 1 1 - - -
3(A) 0 0 0 1 1 - - -
4(A) 0 0 0 0 1 1 - - -
5(A) 0 0 0 0 0 1 1 - - -
6(A) 0 0 0 0 0 0 1 1 - -
1(B) 1 0 0 - - -
2(B) 1 1 0 0 - - -
3(B) 1 1 1 0 0 - - -
4(B) 1 1 1 1 0 0 - - -
5(B) 1 1 1 1 1 0 0 - - -
6(B) 1 1 1 1 1 1 0 0 -

FIG.8

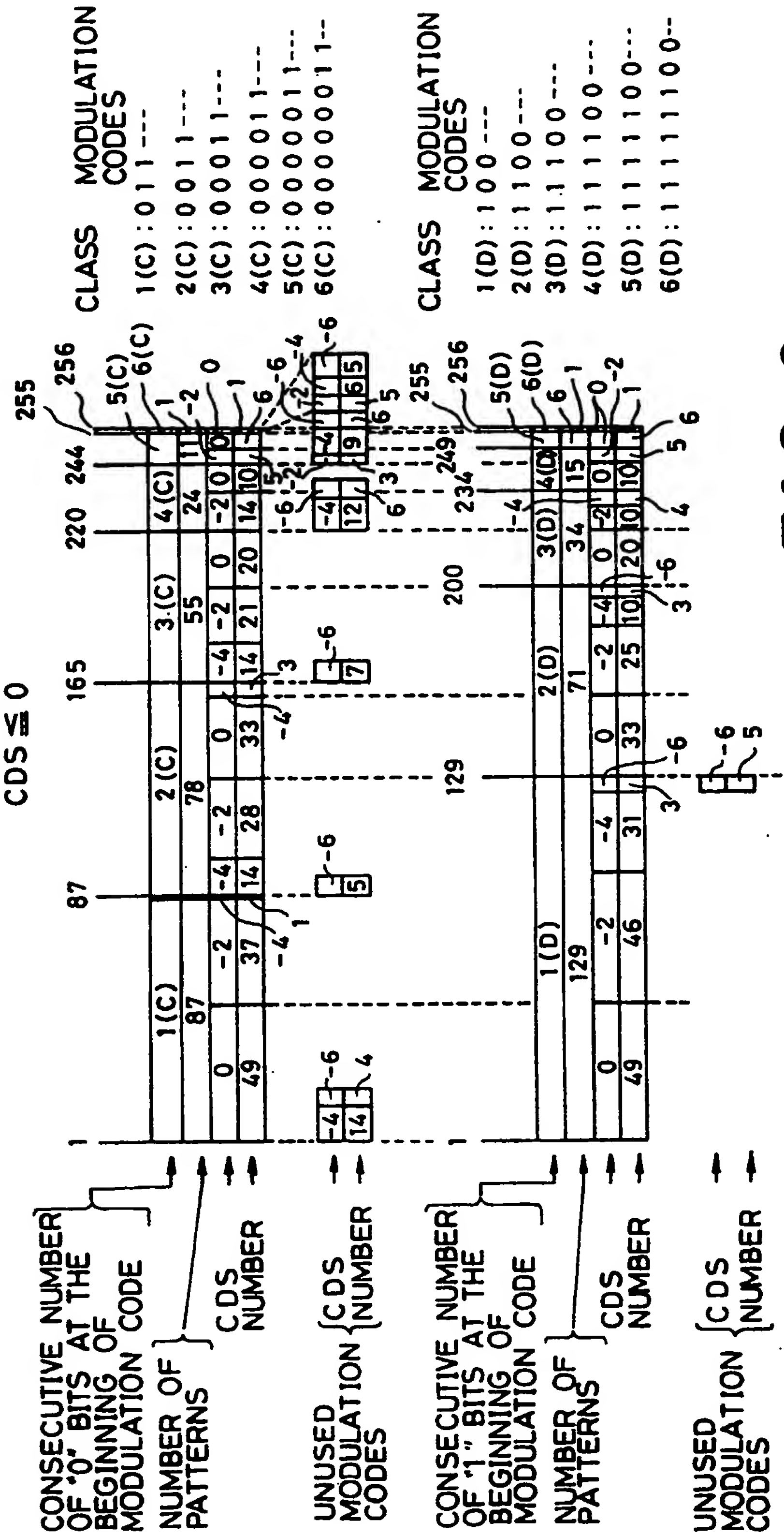

CDS ≦ 0
CONSECUTIVE NUMBER OF "0" BITS AT THE BEGINNING OF MODULATION CODE
NUMBER OF PATTERNS
CDS NUMBER
UNUSED MODULATION CODES
CDS NUMBER
CONSECUTIVE NUMBER OF "1" BITS AT THE BEGINNING OF MODULATION CODE
NUMBER OF PATTERNS
CDS NUMBER
UNUSED MODULATION CODES
CDS NUMBER
CLASS MODULATION CODES
1(C) : 0 1 1 ---
2(C) : 0 0 1 1 ---
3(C) : 0 0 0 1 1 ---
4(C) : 0 0 0 0 1 1 ---
5(C) : 0 0 0 0 0 1 1 ---
6(C) : 0 0 0 0 0 0 1 1 --
CLASS MODULATION CODES
1(D) : 1 0 0 ---
2(D) : 1 1 0 0 ---
3(D) : 1 1 1 0 0 ---
4(D) : 1 1 1 1 0 0 ---
5(D) : 1 1 1 1 1 0 0 ---
6(D) : 1 1 1 1 1 1 0 0 --

FIG.9